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CHEAP TRACTION ON TRAMWAYS.

THE question of cheap railways is the order of the day. Every one, merchant and manufacturer, feels the necessity of developing this valuable means of communication. We readily accustom ourselves to narrow gauge railways of one meter and even of 0·6 meter, the costs of construction and exploitation of which are in harmony with the receipts, and which are capable of yielding a profit, while at the same time responding perfectly to the needs of the small places that they do duty for.

Mr. Noblemaire, manager of the Paris, Lyons and Mediterranean Railway Company, in a recent note of great interest, has brought into relief the services that the departmental railways of 0·6 meter gauge are destined to render to those regions which, owing to their small traffic, cannot afford the luxury of a railway of normal gauge.

The urban and provincial tramways are, in another order of ideas, destined to render the same service as the departmental ones. Their utility in many cases is even more evident, for connecting, for example, the center of the large cities with the populous suburbs. So, in recent years, a large number of these small lines have been constructed in France, as well as in other countries. But, in order to be logical, attention has been directed toward the replacing of animal traction, which has been employed up to recent times, by mechanical traction, which, while being cheaper, permits of obtaining greater speed, and, as to power, presents a much greater elasticity.

Several motors, steam as well as compressed air, and even electric ones, adapted to this kind of traction, have been applied upon recently constructed lines.

Mr. Rowan, formerly a railway engineer, who, for a number of years, has been paying particular attention to the subject of cheap traction on railways, has had tried with success, at Paris, a motor of his invention which has already received the indorsement of a prolonged practice in several large cities in foreign countries and also in France, especially upon the line from Tours to Vouvray, which is a model of its kind as regards regularity of service and cheapness of traction.

We likewise saw it at Paris, during the exposition of 1889, between Place Pigalle and the Trocadero. Since the beginning of the month of September, 1891, the Auteuil-Boulogne tramway line has been employing six Rowan motors.

These automobile engines emit neither smoke nor steam, owing to their special system of condensation. It is a new experiment which is being continued by the Compagnie Generale des Omnibus, which is much interested in its Louvre-Versailles, Sevres and Saint Cloud lines, upon which it is soon to apply mechanical traction. Fig. 1 shows the general aspect of this motor, which, as well as the car behind it, is provided with the Lemoine continuous brake, operated by a simple motion of the engineman's foot.

The main characteristic of the Rowan motor consists in the fact that it is placed in the car itself instead of the latter being hitched to it. A portion of the weight of this car is thus added to that of the motor, in order to constitute the engine's adhesion, which on tramways needs to be relatively strong in consequence of the slippery state of the rails, which are often covered with mud. This motor can thus be much lighter than other steam engines or compressed air ones designed for traction upon tramways. This is a matter of considerable importance, being given the declivities of the road, which are often pronounced, and which cause a heavy engine to expend, in order to propel itself, a large portion of the work that it is capable of producing. The car is carried upon two trucks, which are capable of turning independently of each other. The first truck, which is composed of four wheels, carries the motor, and the second carries only the box, which is very light; and it has only one axle that is fixed. The forward truck, on the contrary, is movable, and may be removed with the greatest ease, in but a few minutes, from beneath the car by making the front of the latter rest upon any kind of support.

This arrangement offers the advantage of not throwing the car out of service when the motor needs cleaning or repairing. Another motor is then introduced between the sole bars, and the car is ready to resume operation. Mr. Rowan has constructed, according to the requirements of the localities in which his system is to be used, motors of various powers and various types, the principal ones of which we shall make known.

For lines of slight gradients, in the first place, he employs an ordinary locomotive boiler and mechanism. But such a boiler is not adapted for steep gradients, the tubes being too short to utilize completely the heat of combustion of the coal, and the vaporization not being active enough therein. Moreover, the interior of the boiler becomes very easily incrusted, and is cleaned with difficulty. For such lines the inventor, in 1885, devised the generator represented in Fig. 2.

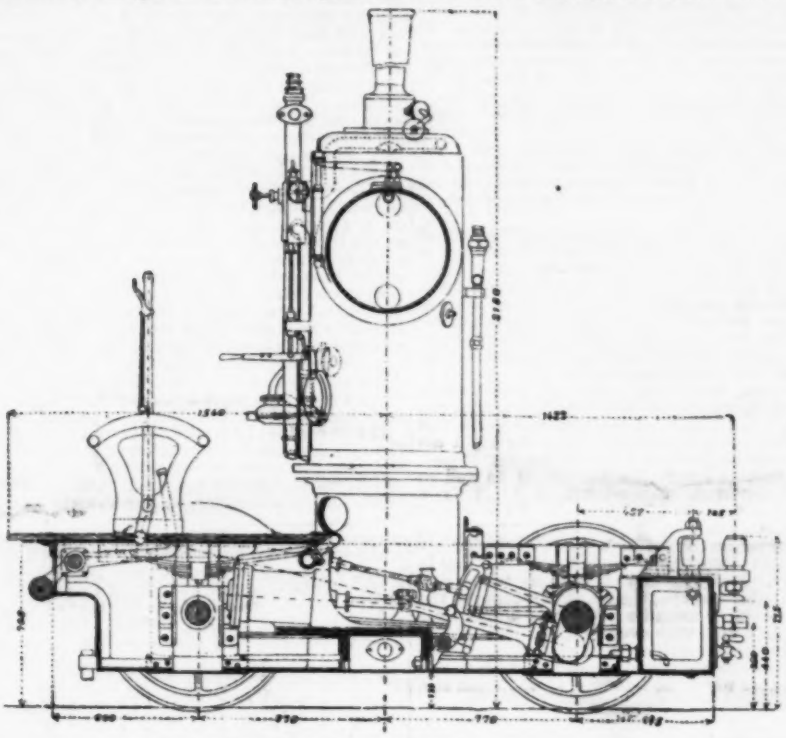


FIG. 3.—LONGITUDINAL SECTION.

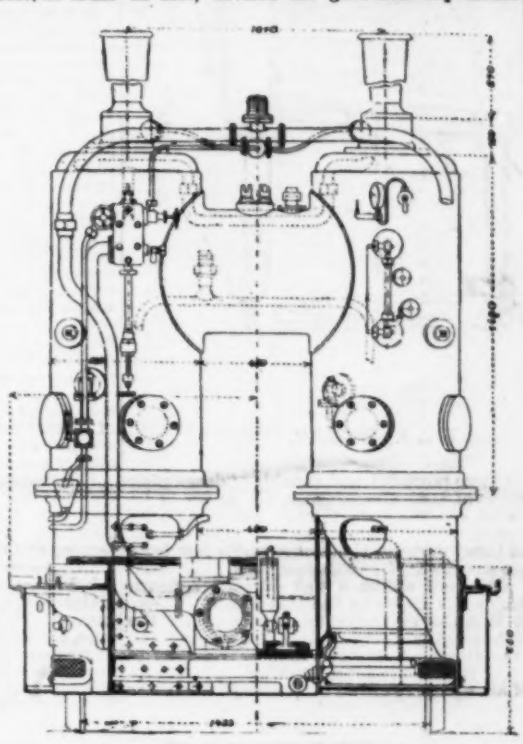


FIG. 5.—TRANSVERSE SECTION

This boiler, fired with coal wa.er, is capable of giving in 35 minutes a pressure sufficiently high to permit of the starting of the car, while it requires an hour and forty minutes to reach the same result with a locomotive boiler of equivalent power. This is a statement made officially by a jury at the Exposition of Anvers, in 1885.

The arrangement shown in Figs. 3, 4, and 5 is particularly powerful. It consists of two vertical shells connected by a horizontal part of the same diameter through which the circulation of the water takes place. The shell of the boiler is cylindrical, but the internal parts are planes, and are connected by a series of inclined tubes (Fig. 2) arranged in two perpendicular axes, and in which the water circulates with great activity.

The bottom tubes, which are nearest the fire, have a larger diameter than the interior ones, in order that the flames may circulate therein with greater facility and that the mass of water offered to the radiations of the fuel may have a sufficiently large volume. The fuel employed is coke. No smoke is ever produced, since the combustible gases are well mixed, and burn perfectly.

One square meter of heating surface of this boiler yields as abundant a vaporization as one meter and a half of surface in an ordinary tramway locomotive boiler. This well shows the power of vaporization and traction of this little motor.

This kind of boiler is inexplosive. A superheating of a few of the tubes merely produces a leak, which is attended with no danger and quickly extinguishes the fire.

The boiler is installed in the center of the frame between the two axles. The cylinders, as well as all the other parts of the mechanism, are placed in the axis of the motor between the two vertical shells. This arrangement completely protects the movement

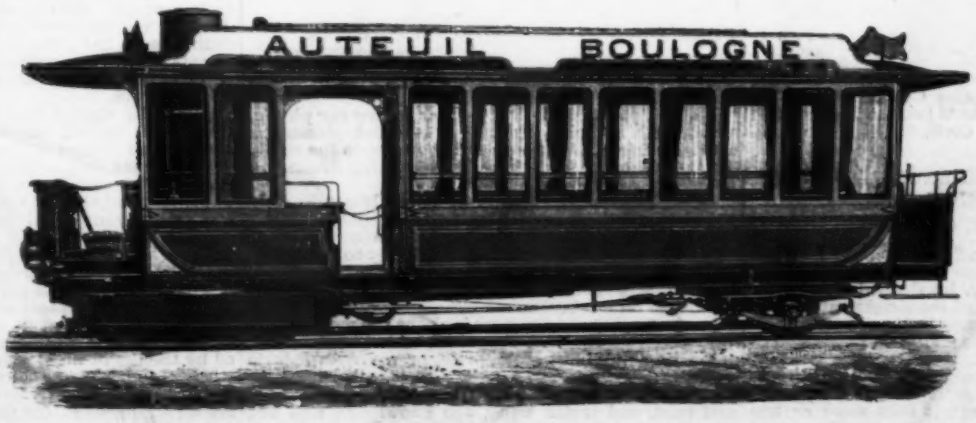


FIG. 1.—AUTOMOBILE STEAM CAR OF THE AUTEUIL-BOULOGNE TRAMWAY LINE.

against mud and dust, and, at the same time, renders inspection easy.

This double boiler motor is constructed in two models of different dimensions. The smaller one weighs 3,800 kilogrammes empty, its vaporization is 500 liters per hour, and its tractive stress is 400 kilogrammes. The longer one weighs 6,000 kilogrammes empty, its vaporization may attain 1,000 liters per hour, and its tractive stress is 1,100 kilogrammes.

Finally, Mr. Rowan has constructed another type,

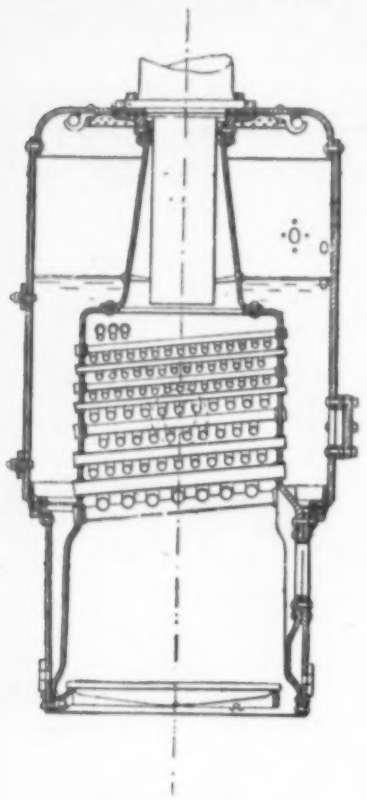


FIG. 2.—BOILER.

which is still more powerful, and capable of developing a tractive stress of 3,000 kilogrammes, and in which he has substituted traction by adhesion for traction by rack and pinion.

In each of these systems, the steam on its exit from the cylinders enters a surface condenser, and, converted into water, afterward enters a tank situated beneath the car, whence it is drawn by the feed pump.

Owing to this, the engine emits no steam, and the feed water, thoroughly purified, does not incrust the boiler, all the tubes are smooth, and the facility of transmission of the heat is not diminished.

In case of an excessive crowd of passengers, such as

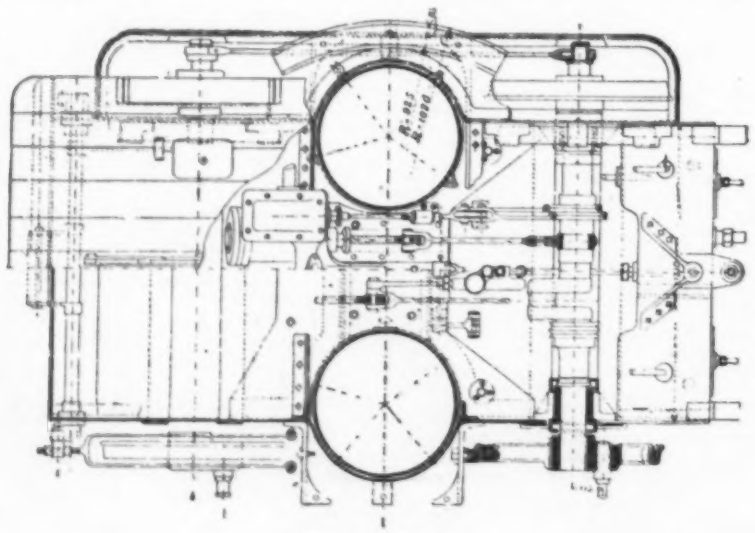


FIG. 4.—PLAN.

appears on Sunday, at Paris, on the Louvre-Versailles, Louvre-Sevres and Louvre-Saint Cloud lines, the engine is powerful enough to haul two and even three cars in all seasons.—*Le Genie Civil.*

ENGINEERING AS A SCIENCE AND AS A PROFESSION.

By JOHN M. ORR.

WHAT is meant by the term "engineering"? What is included in it?

It may, perhaps imperfectly, be defined as the exploration of the constituents of inanimate nature; the codification of the laws governing it, the reduction and application of its forces and its materials to the practical uses of mankind.

Mathematics is its cousin german and its indispensable ally, by the aid of which it becomes, approximately, an exact science, though it falls more or less short of that perfection through the interference of natural sequences which cannot be wholly anticipated, nor be absolutely guarded against, though the possibility of such interference is, year by year, diminished by the results of experiment, and by the accumulating knowledge of the elementary causes which thus may interfere with the attainment of certainty in the engineer's prevision of the operations of inanimate nature.

In this view enginering is a science—that is, a far-reaching, organized *knowledge*—of the highest grade; one which contributes, in an unexcelled degree, to the material good of mankind, and one without which their physical wants cannot be supplied; one by which the supplies for these wants, prepared and deposited by the Creator, are developed and made available *pari passu* with the growth of the needs of the great human family.

Engineering is no merely abstract science, stopping short at the vindication of theories, or even at genuine discoveries. Its pre-eminent purpose is to turn the abstract into the concrete. Its objective point is *actual utility*, the application to present use of whatever is or may become known, and can be proved to be true and reliable in physics.

It is a great dissolvent of theories without bases in facts.

It is grand, for its thoroughness of investigation and the width of its range—the whole field of inanimate nature.

It is grand, too, for the need mankind have for it, and for the benefits its results produce. It is eminently a most useful science. Its promise for the future, for what it shall yet accomplish for human welfare, no man can measure.

It is no narrow pursuit; it is not limited to one single branch of knowledge or research, as many suppose. It is a tree whose roots reach deep down into the arcana of nature, and feed a giant trunk and its many branches. It gives full employment to the highest faculties in each and every of its specialties, civil or military. There are electric engineering, hydrographic, topographical, mining, mechanical, etc., for its inquiries embrace all that belongs to inanimate nature, and yet each special branch is so bound to all the others that any research in one brings knowledge appertaining to the others, and all branches are connected in one common brotherhood of usefulness.

As a pursuit engineering is surely and truly a learned profession, based upon the knowledge gathered in the past, layer on layer, stratum on stratum, course upon course, until it has become the accumulation from which the minds of the present are drawing, and to which they are adding, day by day, materials of infinitely increasing value, an accumulation of practical knowledge the application of which is constantly making human life easier and happier.

As a profession, faithfully practiced, engineering calls for all the capacities for labor, all the endowments of intellectuality, all gifts of patient and impartial analysis and synthesis, a judicial ability for rigid accuracy and severe truth in its conclusions.

It demands in high degree the *perceptive* as well as the reflective faculties, and, withal, of all men a thorough engineer needs that rare faculty of sound judgment which we call "common sense" to test and temper and anneal all his theories.

It is a source of magnificent educational training to mind and body. Every faculty of both is taxed and trained—the limbs, the eye, the hand, the temper, the nerves. The engineer must be a judge of human nature, for he has to deal with every variety of mind and character. He must combine firmness with self-control, clearheadedness with rigid honesty and fidelity to the rights of those whom he represents. He must, too, be a correct judge of every production of nature which he may have to pass on.

There is no calling in life, neither in law nor physic, which calls more faculties into use, and presents a greater variety of subjects of all grades to the mind. The true engineer is continually educating *himself* in the great university of nature.

The operations of an engineer bring him into close association with *realities*—not with impalpable and fine-spun fancies—with the realities of nature herself; and to those who love her and seek truly to know her, she, with maternal affection, bestows royal gifts of knowledge, wide breadth of mind, with vigor of body nourished on her bosom.

In one respect the engineer is above the mere *savant* who pecks at the vast mountain of knowledge, and, when he chips off a little piece, or uncovers a little space, at once elevates himself into a grand inventor or creator of knowledge above even the God who made and used, and is still using, the knowledge, and but lets the *savant* see a glimpse of it. The engineer's habit and training is to bring discoveries to their real measure, and he at least can realize the proportion between what has become known and what is still unknown, and that his Maker is still the possessor in perfection of the knowledge which he is searching for.

It is not every one who can be an engineer. It is not every one, though liberally endowed with brains, who can be a first class farmer, mechanic, jurist, doctor, or clergyman. Many who would excel in one calling fail in some other unadapted to them. Many a good doctor is spoiled in an inferior jurist.

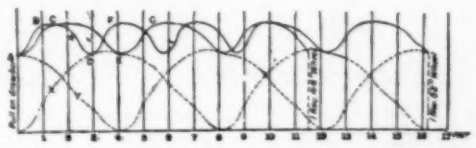
But to one whose bent and adaptation is to engineering there is no wider, nobler, or more fascinating profession (other than that of the clergy), none which is doing more to create a community of interests and intercourse among nations, or to bring the diverse peoples of the earth into closer identity by a unity of supply of wants and needs they have in common.

This crude paper is not intended to be exhaustive. It is meant simply as suggestive of thought in others. If it succeed in this, it is content to be as the seed, which, though reproduced in the crop, is duly buried and forgotten.—*Lehigh Quarterly.*

STARTING POWER OF LARGE AND SMALL WHEEL LOCOMOTIVES.

THE experience of locomotive runners is essentially the same regarding the starting powers of large and small wheel locomotives. When the cylinder power for two engines, in proportion to the diameters of the drivers and the weights on them, is the same for both, the one with the smaller wheels will pull the heavier load out of a bad place, such as a crooked siding with bad tracks. This fact has been much disputed by those who have held that equal starting powers are obtained when the cylinders are made in the same proportion to the diameter of the wheels and the weights. This, like the proper opening of a throttle lever, the wetness of the steam and the counterbalancing of the engine, is a matter which is best settled and best proved by experience. There are conditions under which it is better to run with a partially closed throttle, and however closely a counterbalance may be calculated, yet the effect of any system of counterbalancing on a given engine can only be determined by trial, as the total weight of the engine and the location of the parts have much to do with the exact result. It is not easily seen why two locomotives having the same weight on drivers and the same cylinder power in proportion to the wheels should not draw out of a bad place the same load with equal facility. We have made an analysis of the hauling power at each point of a revolution for a small and a large wheel to show wherein the difference lies. If it is true that the engine with the small wheel can start a heavier load than the engine with a large wheel, then it can be proved.

If two engines have the same weight on drivers and the cylinders are in proportion to the wheel diameters, then the maximum, minimum and average pull which can be exerted by the two engines will be the same for both. Each revolution of the drivers will give four maximum and four minimum points of tractive power for each engine; but in the case of the engine with the small wheel, the maximum points, as well as the minimum, will be closer together, and the momentum of the train may be sufficient to keep it in motion from one maximum point to another in the case of a small wheel, where it might not be sufficient with a large wheel. This is perhaps best shown by the diagram, which is



drawn for a comparison of two locomotives with the same weight on drivers with cylinder power in proportion to the diameter of the wheels, one set of drivers being 44 in. in diameter, and the other 62 in. The vertical lines of the diagram are spread one foot apart and represent one foot of track, while the height of the curved lines above the base represents the pull on the drawbar at different points of the track during one revolution.

The curves start together at A, both at the same minimum pull on drawbar, but with a small wheel the maximum pull is reached at B some distance in advance of the maximum pull for the large wheel at C. The minimum is found at D for the small wheel, and at E for the large wheel. The distance from one point of maximum pull with the small wheel to the next maximum, say from B to F, is considerably less than the distance from C to G with the large wheel, and the momentum of the train, which is obtained by running up on the slack between cars, might often carry the train over from H to F, while it would not do so from J to G. The line from A to B rises much more rapidly than from A to C, showing that if the locomotive attempts to start at a minimum point of pull, its power will more rapidly increase with a small wheel than with a large wheel.

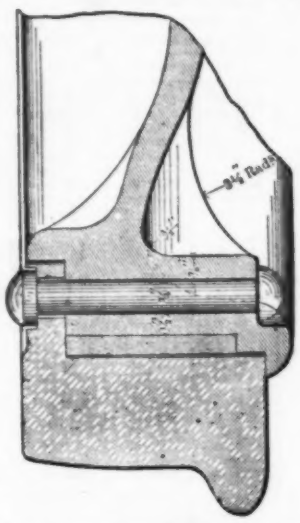
It may be argued that if both locomotives were to start at B and C, the points of maximum pull, the large wheel engine would have an advantage, as the period of maximum pull is longer with the large wheel engine. This is true; but it is not at the point of maximum pull that there is difficulty in starting the train. It is at the point of minimum traction that the difficulty is experienced, and it is probably only during the first two revolutions that this argument applies in any case. To start a freight train when it is in a bad place it is necessary to get the maximum pull as quickly as possible and store sufficient energy in the train by the time the slack is taken up to carry the train over the point of minimum pull, and this is accomplished by the use of small wheels to a greater extent than with large wheels, as shown by the experience of locomotive runners and by the diagram herewith. This is not an argument for the use of small wheels, but simply a statement of comparative starting power.—*Railroad Gazette.*

THE CUSHIONED CAR WHEEL.

THE Cushioned Car Wheel Company, of Indianapolis, has had in service for some time a number of its cushioned car wheels under a coach on the Indianapolis, Decatur & Western Railroad, and a recent examination of these wheels has shown that the amount of wear upon the tires has been exceedingly small. The wheels are 33 in. in diameter, and were placed under a coach which was in regular service on an accommodation train averaging one stop in every four miles, thus making the test more severe than on a through coach. On November 24 of this year the wheels were examined and measured by Mr. McKenna, the master mechanic of the road, with the following results: The wheels on axle No. 1 were taken out after having made 35,000 miles and turned. They afterward made 45,480 miles, and during that time the thickness of the tire was reduced 1-32 of an inch from that at which it left the lathe. The wheels on axle No. 2 had made 72,480 miles, and on the left side of the coach the thickness of the tire was reduced 3-32 in.; on the right side a little more than 1-16 in. The wheels on axle No. 3 had made the same mileage as that of No. 2, namely, 72,480 miles, and the left wheel was found to be worn down 3-32 in. in thickness, while on the right side it was found to be reduced 5-64 in.

In the accompanying illustration we show the construction of these wheels. The center is made either of cast iron or steel, preferably the latter, and either in the plate or spoke form. If the plate center is used, it is made of a form very much resembling the single plate cast wheel. When once on the axle, it is not intended that it shall be removed for ordinary repairs, all that is necessary being to remove the tire from the center. The latter is made as light as is consistent with safety and strength. The tire is of the regular standard form at the tread, and has a flange on its outer face through which it is bolted to the center, as will be readily understood from our illustrations. The center also has a flange projecting so as to engage the inner face of the tire, and thus take the lateral strain from the tire flange through which the bolts pass.

Between the tire and its center there is a rubber strip three-eighths in. thick. In order to press this tire on



THE CUSHIONED STREET CAR WHEEL.

over this cushion without danger of damaging it, the latter is covered with a shield in the shape of a steel band 1-32 in. thick. To facilitate the removal of the tire, it is bored out with a taper of about 1-16 of an in. It is claimed that the use of this cushion makes the wheel practically noiseless and absorbs the vibration caused by uneven track, thus relieving the rails of undue stress from the hammer blows which they so often receive. It is also claimed in favor of the wheels that the cushion greatly reduces the vibration of the wheel center and axle, thereby preventing all tendency of crystallization in the latter. The rubber cushion is practically indestructible, and those in the wheels that made the record above mentioned are in perfect condition. They are relieved from all lateral stress by means of the flanges on the center and tire.

The tire itself is so securely bolted to the center that it is thought there is very little danger from broken tires, as the various parts would be retained in place. The bolts or rivets are fitted neatly in the wheel center, but the hole in the tire flange is drilled one-eighth of an inch larger than the body of the plate, to permit the elasticity of the cushion to be effective. Either bolts or rivets may be used to fasten the tires to the center, but if bolts are employed, they are riveted over the nuts, so as to make everything secure.—*Railway Review.*

AN ESTIMATE OF THE NET COST OF WORKING WITH POWER PRODUCED ON THE PREMISES BY SMALL MOTORS.*

AT a conference held by the Association of Mining Engineers, of Barmen and the neighboring towns, M. Korte presented a very interesting paper on the subject of small motors, the general features of which are presented below, as taken from the report made by the *Journal of the Association of German Engineers.*

The expenses of running motors are too often calculated in an incomplete manner. Either purposely or otherwise, those factors are overlooked which would show the result to have been obtained under conditions very different from the true ones. The author in the present case has endeavored to avoid this fault, as may be judged from the following:

Here we have the entire classification adopted for all motors employed in the smaller industries:

1st. Motors capable of being fed from a central station—water, gas, electric, and compressed air.

2d. Motors not found under the preceding heading—steam, hot air, and petroleum.

I have studied, said M. Korte, all the motors of the first class; but among those of the second, only the steam engine and the hot air motor. I have omitted the petroleum motor (which is, in my opinion, of very great importance),* since the method of setting it up is essentially similar to that of a gas motor, and as the calculation of cost of running this sort of engine is very simple.

Remarks on Table No. I.—Gas Motors.—This table has been compiled by taking as a basis the cost of and figures for consumption as given by Deutz in his manufacture of gas engines. These figures for consumption have been confirmed by various experiments and tests, those made by Slaby among others. I have supposed that the materials employed in all these machines are, as a general rule, of the best quality.*

These calculations are based on an actual running period of from 10 to 5 hours per day, for 300 working days per year. The use of any shorter working periods would have complicated the task beyond measure.

I have further presupposed in every case that the motors ought to furnish their nominal return. As this hypothesis is never entirely realized in practice, but, on the contrary, in the majority of cases, the entire power of the motor is not employed, the cost of running, calculated in horse power per hour, ought never to be considered other than as *minima.*

The same is true of the figures in the other tables. The observation made above upon the advantage to be

TABLE No. I.—*Gas Motors.*

	Vertical Motors.		Horizontal Motors.				
	½ H.P.	¾ H.P.	1 H.P.	2 H.P.	3 H.P.	4 H.P.	6 H.P.
1. Cost of motor, including bolts for fastenings	$156 81	$200 80	$351 66	$446 31	$535 85	$630 31	$868 80
2. Sum of net cost of condenser and pipes ($6.03½ + 4 per cent. of above cost)	12 30	17 61	20 31	25 66	27 45	31 60	40 77
3. Freight and setting up	7 96	10 62	13 06	13 75	15 44	17 61	22 30
4. Expenses for foundations ($4.82½ + $3.61½ × number of horse power)	5 73	6 63	8 44	12 06	15 66	19 27	26 49
5. Sundry expenses in starting	4 10	4 83	5 79	7 96	10 13	12 30	16 68
Total expense of first establishing	$186 90	$229 19	$400 66	$503 38	$604 30	$720 09	$964 64
Cost of Running for 3,000 Hours (10 Hours per Diem.)							
6. Interest, sinking fund and repairs (4 pr.ct. + 5 pr.ct. + 2 pr.ct. = say 11 pr.ct. on first establishing)	$20 57	$36 21	$44 05	$55 44	$66 52	$79 21	$106 13
7. Expenses connected with the gas— Consumption per hour, in cubic feet	17.68625	24.72125	35.3125	70.6250	100.625	134.2027	190.7091
Cost at rate of $0.683 per 1,000 cubic feet	$30 19	$50 68	$72 26	$144 75	$206 17	$273 05	$390 65
8. Cost of oiling and wiping per hour ($0.0012625 + $0.0024125 per horse power)	5 43	7 24	10 86	18 09	25 33	32 57	47 04
9. Overhauling and cleaning (100 to 180 hours per year, at $0.0965)	9 65	10 13	10 86	11 58	12 06	13 03	14 48
10. Rent of premises, etc.	4 83	5 55	6 03	7 24	8 44	9 65	12 06
11. Light and miscellaneous expenses	2 41	2 41	3 90	3 69	4 34	5 07	6 51
Total expenses for running for one year	$79 07	$112 20	$147 96	$240 73	$322 26	$414 56	$477 17
Entire cost per horse-hour	106	075	048	041	036	034	031
Cost of gas alone per horse-hour	048	034	024	024	024	022	022
Summing up of other expenses per horse-hour	058	041	024	017	012	013	01
Expenses of Running for 1,500 Hours (5 Hours per Diem.)							
Items 6, 10 and 11 as above, total	$27 81	$44 17	$53 88	$66 30	$79 70	$92 93	$124 82
Cost of gas—half of the amounts of item No. 7	15 09	25 33	36 12	72 38	103 09	137 51	195 41
Cost of oiling and wiping—two-thirds the amounts for item No. 8	3 62	4 82	7 24	12 06	16 89	21 72	31 36
Overhauling and cleaning (from 70 to 110 hours)	6 76	7 24	7 72	8 44	9 17	9 65	10 86
Total running expenses	$54 28	$81 57	$105 08	$159 18	$207 85	$263 81	$362 45
Running expenses per horse-hour	180	109	070	053	046	043	041

TABLE No. II.—*Hydraulic Motors.*

	¼ H.P.	½ H.P.	1 H.P.	2 H.P.
1. Cost of motor, including setting	$108 56	$139 93	$193 00	$265 39
2. Expenses of starting	3 79	4 76	8 44	12 06
3. Pipe system of influx and discharge	13 68	17 61	21 23	23 16
4. Accessories	2 41	2 90	3 62	4 83
Total cost of establishing plant	$132 44	$167 70	$226 39	$305 43
Running Expenses for 3,000 Hours (10 Hours per Diem.)				
5. Interest, sinking fund and repairs—say a total of 11 pr.ct. on first cost	$14 57	$18 39	$24 89	$33 60
6. Tax for water at a pressure of 6 atmospheres (city water)	108 56	217 13	419 78	810 60
Consumption per hour, in gallons	396.263	792.525	1483.967	2968.76
7. Rent of water meter	$2 41	$2 90	$3 14	$3 14
8. Cost for oiling and wiping ($1.21 + .0012625 per horse-hour)	2 17	3 14	4 83	8 44
9. Overhauling and cleaning, at a rate of $0 0965 per hour, 50 to 75 hours	4 83	5 31	6 03	7 24
10. Rent and miscellaneous expenses	4 83	6 03	8 44	12 06
Total annual expenses	$137 37	$253 90	$467 11	$875 09
Cost of running per horse-hour	1834	1689	1568	1448
Total of the expenses for water alone per horse-hour	1448	1448	1399	1351
Total of the other expenses equally per horse-hour	0386	0241	0169	0097
Expenses for 1,500 Hours (5 Hours per Diem.)				
Items 5, 7 and 10, as above, together	$21 81	$27 32	$36 47	$48 80
Items 8 and 9, two-thirds of the above charges	4 67	5 63	7 24	10 45
Tax for water under pressure	54 28	108 57	209 89	405 30
Total annual expenses	$80 76	$141 52	$253 60	$464 55
Cost of running per horse-hour	2147	1882	1882	1544
Cost of water alone, as above, per horse-hour	1448	1448	1448	1351
Other charges per horse-hour	0700	0434	0434	0193

TABLE No. III.—*Electric Motors.*

	¼ H.P.	½ H.P.	1 H.P.	2 H.P.	3 H.P.
1. Cost of the motor, including setting up	$63 93	$86 06	$106 15	$154 40	$197 83
2. Foundations, etc	5 79	6 76	8 44	12 06	15 68
3. Connections with the conductor main	15 68	17 61	21 23	23 16	25 33
4. Various expenses	2 41	2 90	3 62	4 83	6 03
Total expense of first establishing	$87 81	$113 33	$139 44	$194 45	$244 87
Cost of Running for 3,600 Hours (10 Hours per Diem).					
5. Interest, sinking fund and repairs, including the replacing of brushes—altogether about 14 per cent. of first establishing	$12 29	$16 15	$19 52	$27 22	$34 28
6. Net cost of current, with an average tension of 110 volts as a limit; consumption of current in amperes	3 amp.	5 amp.	9.05 amp	18 amp	26 amp.
Cost at a rate of $0.0183 per ampere-hour	$173 70	$289 50	$534 00	$1,042 20	$1,505 40
7. Oil and materials for lubricating	2 17	3 14	4 83	8 44	12 06
8. Overhauling and cleaning, as for the hydraulic motor	4 83	5 31	6 03	7 24	8 44
9. Miscellaneous expenses	4 83	6 03	7 24	9 65	12 06
Total running expenses	$197 72	$320 13	$561 62	$1,094 75	$1,573 24
Cost per horse-hour	2630	2123	1954	1834	1737
Cost of current alone per horse-hour	2316	1930	1834	1737	1665
Other expenses	0314	0193	0121	0097	0072
Cost of Running for 1,800 Hours (5 Hours per Diem).					
Interest, sinking fund and repairs	$12 29	$16 15	$19 52	$27 22	$34 28
Current	86 85	144 75	283 00	521 10	752 70
Miscellaneous expenses	4 83	6 03	7 24	9 65	12 06
Oiling and overhauling (items 7 and 8)	4 59	5 33	7 24	10 37	13 75
Total annual expenses	$108 56	$172 48	$297 00	$568 34	$812 79
Cost per horse-hour	2895	2292	2051	1906	1800
Taking the below prices for sale of current in Berlin electric works—					
a. Land tax per month	$0 724	$1 33	$2 41	$4 58	$6 76
b. Cost of current per hour	0723	0459	0917	1737	2333
We get the following costs for the current	$0 47	166 40	288 78	501 80	732 88
Cost per horse-hour for 3,000 hours	1520	1383	1086	0965	0803
Cost per horse-hour for 1,800 hours	1785	1472	1183	1013	0941

* Translated for the *American Gas Light Journal*, by Mr. C. S. Davis, from the *Journ. f. des Usines a Gaz.*

* This observation is less true in France than in Germany, because of the increase in France of the customs duty and of other taxes on mineral oils.

* The author has overlooked, in his running expenses, the water used in cooling the cylinder, some 10·267 gals. per horse hour.

found in the use of the best machines is confirmed by the figures given for the motors of the first and of the second group, when the upright engine, whose consumption of gas is very considerable, is placed in comparison with the horizontal engine working under more advantageous conditions. It is seen, in short, that the horizontal motor of one horse power, when it runs at half its power, does not cost appreciably more than the vertical motor of one-half horse power.

Gas motors are received with widely different degrees of approval in different cities. Any one acquainted with the cost of production in making illuminating gas will readily understand that consumers may be guaranteed a very considerable reduction in the price of gas employed as a motive force without thereby seriously affecting the profits. In any case, a powerful impetus would be given to the industry by furnishing gas to motors at a low rate.

The gain in total consumption obtained by a reduction of the price of gas when used as a motor power is well emphasized by the very considerable increase of industry in the city of Barmen. In 1884, when there had been no rebate made in the price of gas (which was then about $1.20 per 1,000 cubic feet), there were forty-one motors in use, representing a total nominal horse power of 117·25; and the annual consumption of gas was some 4,315,676 cubic feet.

In 1885, with a ten per cent. reduction on the price of $1.20 per 1,000 cubic feet, there were in service 70 motors, representing a total nominal horse power of 166·33, with an annual consumption of 5,774,247 cubic feet.

On July 1, 1885, the reduction was increased to 25 per cent., and there were in service after that, until 1887, 125 motors, representing a total nominal horse power of 241·5, with an annual consumption of gas of 8,873,271 cubic feet.

On July 1, 1887, the reduction was again increased, this time to 33 per cent. There were in active operation, from July, 1887, to July, 1888, on an average, 149 motors, representing a total nominal power of 293·75 horse power, and an annual consumption of 15,016,576 cubic feet.

In the year 1889–1890, these figures were further increased to 192 motors, corresponding to a total nominal horse power of 350 and to an annual consumption of 18,419,674 cubic feet of gas.

As the production of gas in Barmen is some 237,403,164 cubic feet, of which 180,508,847 cubic feet are delivered to individuals, the motors consume only 10·2 per cent.

As gas motors are chiefly employed during the day, the production of gas is not under these conditions too heavily taxed by this increase in consumption; and by estimating the profit per 1,000 cubic feet at $0.4782, the gas used for motive power alone gives a profit of $8,807.80. I am firmly convinced that by a further lowering of the price, a very considerable increase would result to the city.

Remarks on Table No. II.—Hydraulic Motors.—This table has been prepared by taking as a base the cost of and the figures for consumption of the Adam House, of Munich. The water pressure is six atmospheres. The running expenses, which, in this case, appear excessive, are due principally to the high cost of the water, as is nearly always the case in cities where water is distributed by private companies or by municipal water works.

Remarks on Table No. III.—Electric Motors.—I have taken into account only the charges for the sale of the current that obtain either in Barmen or in the electric works of Berlin, in spite of having many others placed at my disposal. The town of Barmen sells the current at the same rate both for motors and for lighting purposes, making no reduction either for the one or for the other. But this tariff, as far as the current intended for motors is concerned, is excessive, and, consequently, necessitates considerable expense in running. The charges in Berlin are more moderate. Apparently this cheapness prevails at those electric works which do not themselves consume all the current that they can produce.

Remarks on Table No. IV.—Compressed Air Motors.—These calculations have been worked out upon the established rates of the city of Paris as a base, and may be regarded as a supplement to the general remarks made formerly in the numerous papers of M. Riedler. As this table indicates, the expenses of running a plant must be considered as very high. Perhaps the conditions may be more favorable when the central station in Paris is improved, and the price at which the compressed air is sold has been considerably diminished. The calculations of M. Riedler, relative to the expenses of production of compressed air, fully justify these conclusions. The net costs of running for a period of five hours of service are not exact, except in case there be no interruption.

Remarks on Table No. V.—Steam Motors.—In the cases of those motors presented in this table the boilers have a considerable capacity. When the latter is too small, a frequent feeding of the boiler is necessary, and at quite regular intervals, with the result of considerably increasing the net cost of the motive force. It is necessary to take into consideration, on the other hand, that the cost of heating, in order to raise the water to a temperature giving a working pressure, increases in a direct ratio to the amount of water heated in the boiler, and this fact constitutes an unfavorable factor in cases where *the running is often interrupted*.

It is but right, moreover, to add that *small steam motors are being less and less used* in cases when the *running* is frequently *interrupted*, or only continues a few hours each day.

Remarks on Table No. VI.—Hot Air Motors.—The figures in this table are borrowed from the experiments of M. Slaby. The only motor entering into the consideration is that of the Society of Engine Builders of Berlin—Anhalt.

Remarks on Table No. VII.—Table No. VII. is the most interesting of all. It shows but one gap. There are certain motors from which it is impossible to obtain all the statistics, as may be done in the cases of gas and compressed air motors, with the result that it is impracticable to draw a parallel between all the statistics of these motors.

As an interesting parallel, I give the net cost of motive power from an installation of very large steam engines, and I select for this purpose an installation with which I am very familiar, comprising a tubular boiler, with double furnace, having 968·76 square feet of heating surface, and a compound engine with cylinders of 540 mm. and 800 mm. by 1,100 mm., with Sulzer distribution and with condenser. This machine runs at a pressure of 4·5 atmospheres and at a rate of 60 revolutions, and should furnish 160 horse power.

The expenses of installation are as follows:

Engine, including cost of setting up	$9,000 00
Steam boiler	2,375 00
Pipe system of the boiler	300 00
Engine room	750 00
Boiler rooms (section for each boiler)	325 00
Chimney	875 00
Foundations for the engine	700 00
Masonry work around the boiler	375 00
Other accessories—tools, supplies, and furnishing	225 00
Total cost	$14,925 00

The expenditure of steam is some 18·078 lb. per horse hour, the steam production is 3·082 lb. per square foot of heating surface, and the cost of fuel corresponds to a vaporization of 7 lb. of water per lb. of coal.

In connection with the preceding, the expenses for the motive power are as follows:

Interest at 4 per cent. on the $14,925 above	$297 00
Sinking fund and repairs to the engine and piping, say 5 per cent. on the above, $9,300	465 00
Sinking fund on the cost of the boiler, say 7½ per cent. of the above, $2,375	178 13
Sinking fund on the cost of installation of the boiler room, say 3 per cent. of the $325 above	9 75
Consumption of water: 3,000 × 42·268 × 8·5 = 1,077,834 galls. at $0.01827 per 1,000 galls. (10 hours per diem) say	19 60
Consumption of fuel: 1,275,282 lb. at $0.0165 per lb.	2,104 22
Materials for lubricating and cleaning	300 00
One engineer	275 10
One fireman	275 10
Various incidental expenses	180 72
Total annual cost	$4,354 71

By taking 300 days, and 10 hours per diem working time, we get:

Net annual cost per horse power	$27 73
Net cost per horse hour	0·008932
Fuel alone, per horse hour	0·00454

Table No. VII. summarizes the results given by the preceding tables, but with the necessary limitation that it has been obtained by taking as a working basis the price of gas, water, etc., current only in a limited locality, the city of Barmen. As to the rest, the compressed air and the electric motors are presented with the condition under which they operate at Paris and Berlin.

We see from the results furnished by Table No. VII. that there are no essential differences between the net costs of motive power whether derived from gas, steam, or hot air motors. For minor industries, the gas motor is somewhat the cheapest; but for very extensive use,

TABLE No. IV.—*Compressed Air Motors of Paris.*

	Without Regulator		With Regulator and Single Expansion Cock				
	½ H.P.	½ H.P.	1 H.P.	2 H.P.	3 H.P.	4 H.P.	6 H.P.
1. Cost of motor, including transportation and setting up	$75 50	$112 18	$186 76	$222 69	$290 59	$291 67	$345 71
2. Expenses connected with starting	3 79	6 76	8 44	12 06	15 68	19 30	26 54
3. Pipe connections with the city system, including pressure regulator (without an air reheater) $12.06 ÷ 5 per cent. of cost of motor	15 68	17 81	21 23	23 16	24 85	26 54	29 19
4. To heating the air, and other accessories	14 48	17 37	21 71	29 92	32 07	35 95	42 70
Total expense of first starting	$111 94	$153 92	$237 14	$287 83	$332 19	$373 46	$444 14
Cost of Running for 3,000 Hrs. (10 Hrs. per Diem.)							
5. Interest, sinking fund and repairs—11 per cent. of above total	$12 31	$16 93	$26 09	$31 66	$36 54	$41 08	$48 86
6. Cost of compressed air—							
Consumption compressed air per horse hour	2,472.155 c.ft.	2,118.9 c.ft.	1589.243 c.ft.	1,412.66 c. ft.	1,236.078 c.ft.	1,130.128 c.ft.	882.913 c.ft.
Annual cost for 3,000 hours, at a rate of $0.08197 per 1,000 cu. ft. for compressed air	$151 99	$260 55	$390 83	$694 80	$911 93	$1,111 68	$1,302 75
7. Consumption of fuel in heating the air	00241	00241	00217	00217	00193	00169	00145
(Per horse hour, about $0.00193, at a rate of $3.86 per barrel of oil)	1 81	3 62	6 51	13 03	17 37	20 37	For 1½ horse power 26 06
8. Oiling and tending per hour	00169	00217	00362	00483	00965	00844	01206
" " " " year	5 07	6 51	9 05	14 49	19 89	25 32	36 18
9. Overhauling and cleaning, at $0.0965 per hour, for 150 to 225 hours per year	14 48	14 96	13 68	17 37	19 06	20 75	24 13
10. Rent, hire of comp. air meter, light, insurance, and miscellaneous expenses	10 86	11 58	12 35	14 72	16 89	19 06	23 40
Total running expenses	$196 52	$314 15	$460 71	$796 07	$1,021 68	$1,236 16	$1,461 38
Cost per horse hour	2630	2099	1544	1303	1134	1037	0820
Cost of air and fuel per horse-hour	2051	1761	1327	1183	1037	0941	0748
Other expenses	0379	0338	0217	0121	0097	0097	0072
Cost of Running for 1,500 Hrs. (5 Hrs. per Diem).							
Interest, etc., as above	$12 30	$16 90	$26 06	$31 60	$36 45	$41 02	$48 80
Consumption of air	75 93	130 28	195 41	347 40	433 96	533 84	651 38
Fuel for heating	27	1 93	3 38	6 51	8 69	10 13	13 03
Oil, materials for cleaning, overhauling and cleaning	13 03	14 23	16 41	21 23	26 06	30 88	40 03
Miscellaneous expenses (as in item 10 above)	10 86	11 58	12 35	14 72	16 89	19 06	23 40
Total running expenses	$113 09	$174 92	$253 81	$421 46	$544 05	$656 93	$776 66
Cost per horse-hour	3016	2340	1689	1399	1208	1086	0869
Cost of air and heating alone	2051	1761	1327	1182	1037	0941	0748
Other expenses	0965	0579	0362	0217	0169	0145	0121

TABLE No. V.—*Showing Net Cost of Power Furnished in the Minor Industries by Steam Motors.*

	Allowing for 70 per cent. of the Running			Distribution by Expansion.	
	1 H.P.	2 H.P.	3 H.P.	4 H.P.	6 H.P.
1 Net cost of motor including feed pump and reheater[1]	$343 75	$440 00	$525 00	$662 50	$790 00
2 Cost of transportation and setting up ($5 + 2 per cent. of cost of motor)	11 87	13 80	15 50	18 25	20 80
3 Foundations ($5 + $3 75 × horse power)	8 75	12 50	16 25	20 00	27 50
4 Building chimney or connecting with one already standing	15 25	18 25	20 75	24 75	26 75
5 Miscellaneous expenses	8 00	9 25	10 00	12 00	13 80
Total cost of first establishing	$387 62	$493 80	$587 50	$737 50	$882 55
Cost of Running for 300 Days (10 Hours per Diem.)					
6 Interest, sinking fund and repairs, 4, 5½, and 2½ per cent. respectively, or a total of 12 per cent	$46 42	$59 26	$70 50	$88 60	$106 91
7 Coal—					
Consumption per horse hour in pounds, vaporization 15 lbs. 6 9 oz.[2]	11 023 lbs.	10.141 lbs.	9.640 lbs.	7.540 lbs.	7.540 lbs.
Cost per year at rate of $2.50 per ton	$37 50	$69 00	$96 75	$103 50	$154 00
8 Coal for kindling, per diem ($0 01 + $0.02 × horse power)	03	05	07	09	13
Cost for 300 days	9 00	15 00	21 00	27 00	39 00
9 Net cost of feed supply of water[3]—					
Number gallons consumed per horse-hour	9 246 gals.	8.454 gals.	7 925 gals.	6.340 gals.	6 340 gals.
Cost at a rate of $0 014 per 1,000 gallons	$2 15	$3 78	$5 10	$5 64	$12 96
10. Materials for oiling and wiping by the hour ($0.0006 + $0.00126 × H.P.)	5 63	9 30	13 13	16 88	24 38
11. Overhauling and cleaning (2 to 3 hours per diem, at $0.10)[4]—					
Number hours per year	600 hours.	660 hours.	720 hours.	780 hours.	900 hours.
Cost	60 00	$66 00	$75 00	$78 00	$90 00
12. Rent of premises where the motor is established	6 25	7 50	8 75	10 00	12 50
13. Lighting the engine room, insurance, and miscellaneous	3 00	3 75	4 50	5 25	6 75
Total annual cost	$170 98	$235 62	$294 50	$336 36	$445 63
Cost per horse-hour	$0 0575	$0 0400	$0 0325	$0 0275	$0 0250
Cost of water and fuel per horse-hour	0175	0150	0125	0125	0125
Miscellaneous expenses	0400	0250	0200	0175	0125
Cost of Running for 300 Days of 5 Consecutive Hours.					
Interest, etc., as in item 6 above	$46 42	$59 26	$70 50	$88 00	$105 91
Fuel and water—item 8 above, and items 7 and 9 above at one-half	29 35	52 43	73 50	82 68	122 61
Materials for oiling and cleaning, item 10	3 75	6 25	8 75	11 25	16 25
Overhauling and cleaning—					
Number of hours per year	360 hours.	396 hours.	432 hours.	468 hours.	540 hours.
Cost	$36 00	$39 50	$43 00	$46 75	$54 00
Item 12, as above	6 25	7 50	8 75	10 00	12 50
Miscellaneous	2 34	3 00	3 50	4 50	5 00
Total cost for a year of 1,500 hours	$124 31	$167 94	$208 00	$242 68	$316 27
Cost per horse hour	0825	0550	0450	0400	0350

1 We have had in view those motors established under the most favorable conditions, with boilers holding a considerable supply of water. 2. Including the heating of the water up to the vaporization point. 3. The use of pure water is presumed, supplied by city mains. 4. Including the periodical cleaning of the boiler as well as of the chimney.

TABLE No. VI.—*Net Cost of Power Furnished by Lehmann's Hot Air Machine.*

	½ H.P. Nom'l. ¼ H.P.	¼ H.P.	1 H.P.	2 H.P.
1. Cost of the motor	$337 50	$362 50	$430 00	$637 50
2. Transportation and setting up (as for the steam engine)	11 75	12 25	14 00	17 75
3. Foundations ($5 + $3.75 × horse power)	6 25	7 00	8 75	13 50
4. Constructing chimney, or connecting with a previously existing one	12 50	13 75	15 25	18 25
5. Pipe system for condensation ($3 + 1¼ per cent. of motor's cost)	10 00	10 50	11 75	14 50
6. Miscellaneous expenses connected with installation	6 25	7 00	8 00	9 25
Total cost of first establishing	$384 25	$413 00	$507 75	$709 75
Net Cost of Running 10 Hours.				
7. Interest, sinking fund and repairs (4 + 5½ + 3 = 12½ per cent.)	$48 00	$51 50	$63 50	$88 75
8. Consumption of fuel per hour, in pounds	2.7559 lbs.	4.9606 lbs.	9.3697 lbs.	18.7395 lbs.
Annual cost at a rate of $2.50 per ton	$9 38	$18 75	$33 75	$67 51
9. Consumption of water for condensation, by the hour, in gallons	21.134 gals.	29.059 gals.	52.835 gals.	105.670 gals.
Annual cost at rate of $0.039 per 1,000 gallons	$2 25	$3 25	$6 00	$12 00
10. Coal for firing, in pounds	17.6368 lbs.	26.4552 lbs.	44.092 lbs.	70.5472 lbs.
Cost for 300 days	$6 00	$9 00	$15 00	$24 00
11. Oiling and wiping materials (as for the steam engine)	2 50	3 75	5 50	9 25
12. Overhauling and cleaning: Number of hours	200 hours.	225 hours.	250 hours.	300 hours.
200 to 300 hours, at $0.10 per hour	$20 00	$22 50	$25 00	$30 00
13. Miscellaneous expenses	9 00	10 00	11 25	13 25
Total cost of running	$97 13	$118 75	$160 00	$244 76
Cost per horse-hour	1200	0900	$0 0325	$0 0400
Cost of coal and water only	0225	0200	0175	0175
Cost of remainder	1050	0375	0350	0225
Cost of Running for 5 Consecutive Hours.				
Interest, etc.	$48 00	$51 50	$63 50	$88 75
Fuel	4 75	9 50	17 00	33 75
Firing (as above)	6 00	9 00	15 00	24 00
Water for condensing (one-half the item above)	1 25	1 75	3 00	6 00
Oil, materials for cleaning and overhauling (two-thirds the item above)	15 00	17 50	20 25	26 00
Miscellaneous expenses	9 00	10 00	11 25	13 25
Total annual expenses	$84 00	$99 25	$130 00	$191 75
Cost per horse-hour	$0 2250	$0 1325	$0 0875	$0 0650
Reduction on the net cost of power per horse-hour, at a rate of $3.13 per ton of coal—				
For a running period of 10 hours	1350	0850	0575	0450
For a running period of 5 hours	2350	1400	0925	0700

TABLE No. VII.—*Summary of the Net Cost of Power of Different Motors per Horse-Hour.*

	¼ H.P.		½ H.P.		1 H.P.		2 H.P.		3 H.P.		4 H.P.		5 H.P.	
	10 Hrs. per Day.	5 Hrs. per Day.	10 Hrs. per Day.	5 Hrs. per Day.	10 Hrs. per Day.	5 Hrs. per Day.	10 Hrs. per Day.	5 Hrs. per Day.	10 Hrs. per Day.	5 Hrs. per Day.	10 Hrs. per Day.	5 Hrs. per Day.	10 Hrs. per Day.	5 Hrs. per Day.
	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.	Cents.
1. Gas motor, at rate of $0.849 per 1,000 cu. ft.—														
Total cost	12.00	18.50	8.50	12.00	5.75	7.75	4.75	6.00	4.25	5.25	4.00	5.00	3.75	4.75
Cost for gas alone	6.00		4.25		3.00		3.00		2.75		2.75		2.75	
2. Hydraulic motor, at a rate of $0.849 per 1,000 cu. ft. of water—														
Total cost	22.00	25.25	20.50	22.50	19.00	20.00	18.00	18.75						
Cost of water alone	18.00		18.00		17.50		16.75							
3. Electric motor; at Barmen, 110 watts cost $0.02—														
Total cost	97.25	99.00	22.00	23.50	20.25	21.25	19.00	19.75	18.00	18.75				
Cost of current alone	94.00		2.00		19.00		18.00		17.25					
3a. Electric motor; Berlin rates, about one-half those at Barmen—														
Total cost	15.75	18.50	13.50	15.25	11.25	12.25	10.00	10.50	9.25	10.00				
Cost of current alone	12.50		11.50		10.00		9.00		8.50					
4. Compressed air motor, at a rate of $0.0849 per 1,000 cu. ft. air compressed at Paris—														
Total cost	27.25	31.25	21.75	24.25	16.00	17.50	13.50	14.50	11.75	12.50	10.75	11.25	8.50	9.00
Cost of the air and heating it	21.25		18.25		13.75		12.25		10.75		9.75		7.75	
5. Steam engine for minor industries—														
Coal at $3.12 per ton					6.00	8.75	4.25	6.00	3.50	5.00	3.00	4.25	2.75	3.75
" 3.75 "					6.50	9.25	4.50	6.50	4.00	5.50	3.25	4.75	3.00	4.25
" 6.00 "					7.25	10.25	5.25	7.25	4.99	6.25	4.00	5.25	3.50	4.75
6. Lehmann hot air machine—														
Coal at $3.12 per ton	13.50	23.50	8.50	14.00	5.75	9.25	4.50	7.00						

rather more expensive. It is not very generally considered excepting in its smallest kinds. From this standpoint, then, it will long remain the cheapest motor, and at the same time, by far the most convenient. Even in those localities where coal costs more than $0.3125 (see table), it will remain the cheapest for the first starting up, and as a rule, afterward too, for all purposes where its daily use would be interrupted and irregular.

The statistics for motors of a much larger capacity present a marked agreement between the steam engine and the gas motor. But in those cases where a continuous running is concerned—an uninterrupted daily period—if it is, in addition, found practicable to make use of the waste steam, then it is more advantageous to employ the steam motor, especially where the price of coal is not too high.

In those places where there are no gas works, the Lehmann engine is in every instance a relatively very cheap motor.

As Table No. VII. shows, the electric motor is sensibly on a par with the compressed air motor, as far as the net cost of the motive force is concerned, and in its slender products. Setting aside the reheating apparatus, the employment of which is imperative in compressed air motors, we have at our disposal two convenient sources of motive force. The contest of opinion actually aroused in certain places *apropos* of these two types of motors will, it is to be hoped, aid in introducing such perfection in the central installation of electricity and compressed air that the costs of running will be considerably diminished, to the great profit of the minor industries.

The hydraulic motor, as we have previously remarked, is a very costly source of motive power. But the running expenses may be partially or even entirely done away with in those cases where the water, arriving under pressure, may be again used after its passage through the motor.

The conclusion cannot be drawn from the figures furnished by the tables that any one motor is absolutely the cheapest for every case. But one may find there sufficient data to prevent his making a costly mistake in the selection of an apparatus.

It is really to be regretted that too often the expense of establishing a motor plant precludes giving the preference to a good motor over a bad one.

Finally, as to the valuations employed in the foregoing tables for the items of interest, sinking fund, etc., the expenses for superintending, lubricating, etc., I have doubtless not maintained the strictest accuracy, but I am sure that they approximate very nearly to the true ones.

CANADIAN PROJECT FOR UTILIZING NIAGARA FALLS.

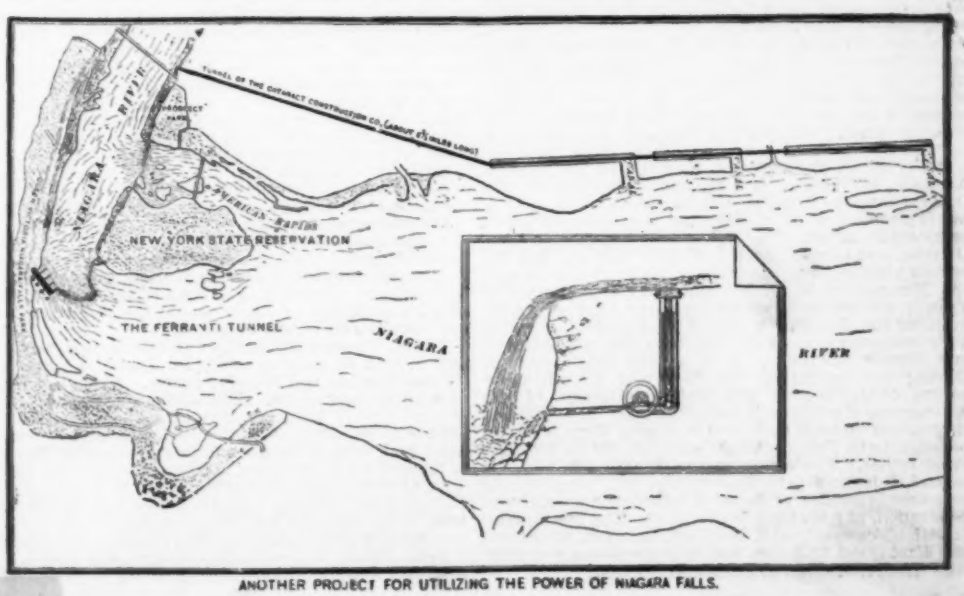
A PROJECT is on foot for the erection upon the Canadian side of the great cataract of a plant for the development of power and its electrical distribution under high voltage to neighboring cities. The responsibility of at least the electrical portion of the enterprise is accredited to Mr. Ziani de Ferranti, whose work at Deptford was the first successful demonstration of the possibilities of transmission to a distance by means of high tension electricity. It is reported that a very strong syndicate of capitalists has obtained a franchise from the Canadian government, and will sink a series of shafts into the bed of the river just above the falls on the Canadian side, as indicated on the lower left hand corner of the accompanying cut. Placed at the top of these shafts are to be heavy iron gratings to prevent the entrance of stones and ice, and the water delivered through vertical iron flumes upon Pelton wheels connected to enormous Ferranti dynamos situated in a subterranean dynamo room, from which a horizontal flume or tail race discharges the water from the wheels at the base of the falls, as indicated in the central sketch. The large machinery tunnel will be extended under the bank with an entrance ashore, and the first vertical shaft sunk upon the edge of the bank, which will upon completion be cut away to admit the water. Further shafts will be sunk, as the demands for power increase, by the use of anchored caissons. Stress is placed upon the flexibility and immediate availability of the system, which can be started into operation as soon as one vertical and one horizontal shaft are completed, and the main or machinery tunnel carried to their point of intersection.—*Power.*

THE FIRST STEAMER TO AUSTRALIA.

PROGRESS in the mercantile marine and commerce of European nations has been productive of remarkable changes, and has been marked by bold and willing determination on the part of our leading steamship companies to keep pace with the order of the day, as can be seen in the achievements and vast improvements made in the costly type and class of vessels employed in our ocean service. The P. & O. company was first known in 1837 by the name of the Peninsular Company, owned by Messrs. Willcox & Anderson, of London, trading with Lisbon and other Peninsular ports. The mails used to be conveyed in sailing packets, under Admiralty control, leaving Falmouth for Lisbon once a week, "wind and weather permitting," and often occupying three weeks in the trip.

The advantage of steam communication was brought under the notice of the English government, and after much difficulty, as well as opposition, a contract for a monthly service from Falmouth to Vigo, Oporto, Lisbon, Cadiz, and Gibraltar was made with Messrs. Willcox & Anderson, in company with Captain Bourne, R.N. This was the first foreign mail contract entered into by the government. In 1840 the company was expanded into the Peninsular and Oriental Steam Navigation Company, incorporated by royal charter. Their first boat was the paddle wheel ss. William Fawcett, of 206 tons and 60 horse power. She heads the long list of 160 ships which have comprised the fleet of the company from its inception. The Peninsular mail service was carried out with such regularity and success as to earn the frequent approval of the Admiralty, and led to the general adoption of the system of conveying foreign mails by contract with private enterprise in place of by ships of the royal navy. In 1844, after negotiations with the government and the East Indian Company, a contract was entered into for the conveyance of mails to Ceylon, Madras, Calcutta, Straits Settlements, and China, the service being commenced on January 1, 1845.

The success of the Indian service found an echo in Australia. An agitation was commenced, and meetings were held in the colonies and in London to secure steam communication with the mother country. It was not till 1847 that the directors of the P. & O. Company were able to approach the government with an offer to carry out the proposed service. They submitted several alternative proposals to the Admiralty, but with no result. At the same time the Board of Trade granted a charter to a company, called the India and Australia Company, for the purpose of establishing a steam service with Australia. The new company was unable to carry out its engagement, and offered to sell its charter to the P. & O. Company for £10,000. In 1852 the second Indian contract included a branch service to Sydney from Singapore, starting once every two months. Very little importance was placed then on the requirements of the Australian colonies, and it is due to the energy of Captain Pasco, who volunteered to accompany the Chusan on her first trip, that the company extended their operations to Australia. The Crimean war caused a suspension of the Australian ocean service, and it was not resumed before 1857, when the colonial governments came forward with liberal grants for a regular monthly communication. The P. & O. Company would not accept the conditions offered, and the service was undertaken by the European & Australian Company, who, however, lost £700,000 in two years, and went into liquidation, and the P. & O. Company took up the work under contract. The open-



ANOTHER PROJECT FOR UTILIZING THE POWER OF NIAGARA FALLS.

ing of the Suez Canal ushered in a new order of things. New fleets had to be built, possessed of greater speed, with such other changes in the carrying service as to harmonize with the new era. We need only go back to 1873 to see how rapid the march of progress has been. In that year the period of transit of mails from London to Bombay was twenty-three days; they are now carried in sixteen days. The Australian mails in 1873 were delivered in forty-eight days; the time is now thirty-five and a half days. The subsidy for the India, China, and Australian contract in 1873 was £580,000, with a monthly mail to Australia. The same service with a fortnightly mail to Australia is now done for £350,000. Rates of freights and passages have diminished; a three months' return ticket can now be obtained for £60, while a return passage to Bombay then cost £180. When the company began operations, fifty years ago, the trade of Great Britain with the East was valued at £20,000,000; it is now equal to £160,000,000.

Telegraphs and submarine cables, the lightning handmaids of commerce, now girdle the earth; nations call to each other across the ocean's expanse, and flash their thoughts and wants to one another. We, at the antipodes, know in a few hours what, fifty years ago, would have taken four or six months to reach us. The latest advantage resulting from the growth of population and increased facilities of ocean communication is the establishment of a reduced rate of over-sea postage, on letters between the colonies and mother country, from 6d. to 2½d. the ½ oz. And thanks to the efforts of Mr. Henniker Heaton, M. P., it is more than likely that, on January 1 of next year, this rate will be further reduced to 1d.

Twenty years ago the average tonnage of the P. & O. Company's ships was 2,058 tons; at the present time the average is over 4,000 tons.

The Orient Steam Navigation Company was formed in 1878, for the special purpose of developing the Australian trade, and came into rivalry with the long established and powerful P. & O. The Orient steamers originally ran monthly, but the rapid increase in the colonial trade induced the company to take up a fortnightly service, carrying mails from London and Plymouth through the Suez Canal to Albany, Adelaide, Melbourne, and Sydney. The fleet of the Orient Company is not so formidable as the P. & O.'s, but it numbers some of the finest specimens of naval architecture afloat. The Ophir, 6,300 tons; the Oroya, Orizaba, and Ormuz, each over 6,000 tons, are fast favorites with passengers. Next in order of merit comes the Messageries Maritimes, under contract with the French government, whose steamers were expressly built for the Australian and New Caledonian trade. This company is most creditable to the enterprise of our French neighbors. It is an old establishment. During the period of the ill-starred French occupation of Mexico, in the sixties, steamers of the Messageries Maritimes Transatlantique distinguished themselves in both mail and transport duty, and ran fortnightly to Tampico and Vera Cruz, *via* St. Thomas, West Indies. The company was founded in 1852. It extended its service to Australia in 1882, constructing new vessels for the purpose, of which the magnificent Australien, of 6,000 tons, is the finest. The Messageries Maritimes connects with Bombay, Reunion, Mauritius, and East Coast of Africa, and conveys passengers overland from Marseilles to Paris and London.

The Germans have not been behindhand in competing for the Australian trade; and the fine steamers of the Norddeutscher Lloyd entered upon the ocean service to the colonies in 1886. The Kaiser Wilhelm II., of 7,000 tons, was the first of the German express line to reach Sydney. The latest competitor is the Deutsche-Australische Company, another direct line from Antwerp and Hamburg, founded in Hamburg as recently as 1888, for the object of developing German trade in the Pacific. Their pioneer steamer was the Elberfeld, a very handsome vessel of the best construction, with a carrying capacity of 4,000 tons dead weight.

Then we have the Anglo-Australian Steam Navigation Company, affording regular steam communication between the colonies, London, Hull, and Bristol. Their steamers are of great capacity, and are fitted with every comfort. The Union Steamship Company, of New Zealand, can be classed among the most successful enterprises of the day. It is purely a colonial concern, and is regarded with pride by New Zealanders as almost a national institution, although it possesses nearly a monopoly of the intercolonial carrying trade of the colony, as well as the San Francisco mail contract. It has a fleet of powerful steamers, of which the Monowai and Mariposa are fine specimens. Besides these there is the Eastern & Australian Steamship Company, trading between Australia and China; also the China Navigation Company. Mention is not included in this article of the large number of fine coasting and intercolonial steamers, but from the foregoing it can be realized with what strides the commerce of the colonies has been advancing. The William Fawcett was, by comparison, to the P. & O. and Orient liners of to-day what the little argosies of Columbus and Drake were to the three-deckers of England's wooden walls. The transition from the little William Fawcett and Chusan to the superb floating palaces that now skim the seas and annihilate distance exceeds anything that could have been dreamed of by those who "went down to the sea in ships" fifty years ago. Science and invention have done wonders in vanquishing many natural obstacles; but they have not yet succeeded in turning the frizzling heat of the Red Sea into cool zephyrs. Yet, what is the rapid passage now made of that route by the side of the discomforts of the old overland journey across the desert from Cairo to Suez, with its scorching heat, sand storms, plagues of flies, fleas, and beggars, with their eternal refrain of "backsheesh." With the elegance and luxury of palatial drawing rooms, ladies' boudoirs, social halls, smoking rooms, dining saloons, with comfortable well ventilated state rooms, brilliant electric light, refrigerating chambers, and cuisine, discipline, and plenty of elbow room, the terrors of deep sea traveling have now departed.

The ss. Chusan, the subject of our sketch, was the first P. & O. steamer to arrive in Australia. She was 699 tons burden and 80 horse power. She was reckoned a smart boat in her time, and a fine model of the clipper type of steamers then in use. No doubt, her arrival in Sydney on August 3, 1852, created more excitement and wonder than is produced to-day by the sight of modern sea monsters of 7,000 tons, such as the Himalaya, Orizaba, and the Australien. The arrival of the Chusan was celebrated with a public ball and supper, held in the Museum ball room on August 26, 1852. A programme of the affair, printed on satin and framed, is to be seen in the company's office, Pitt Street.—*Illustrated Sydney News.*

THE KNOX SYSTEM OF QUARRYING.

WM. L. SAUNDERS.

THE philosophy of the Knox blast is simple, though a matter of some dispute. Mr. Knox gives us the following explanation:

"The two surfaces, *a* and *b*, being of equal area must receive an equal amount of the force generated by the conversion of the explosive into gas. These surfaces being smooth and presenting no angle between the points, A and B, furnish no starting point for fracture, but at these points the lines meet at a sharp angle, including between them a wedge-shaped space. The gas acting equally in all directions from the center is forced into the two opposite wedge-shaped spaces, and the impact being instantaneous, the effect is precisely similar to that of two solid wedges driven from the center by a force equally prompt and energetic. All rocks possess the property of elasticity in a greater or less degree, and this principle being excited to the point of rupture at the points, A and B, the gas enters the crack and the rock is split in a straight line, simply because, under the circumstances, it cannot split any other way."

Another theory has been stated as follows:

"A round hole forms on all sides a perfect arch, and if the rock be sound, it is equally strong in all directions. The making of the grooves at opposite sides of the hole breaks the arch at these sides, thus producing two weak sides and two strong sides at right angles with each other. Force being applied within the hole for the purpose of breaking the rock naturally exerts itself in the lines of weakness which have been produced by destroying the arches at A and B, and they being exactly opposite to each other, the result is that the rock is fractured in a straight line, the gas generated by the explosion acting in these lines in the same manner as a line of wedges would applied from the outer side of a rock, with this difference, viz.: Wedges applied from the outer side of a rock are driven inward toward the point of greatest resistance in the rock, while the gas being confined within the rock at its strongest part and operating toward the outside, or weaker part, will naturally take that direction which will most quickly relieve the pressure, and that is a direct line to the surface."

The effect of the Knox blast being practically the same as that of the old Portland system, or that of Lewising, it is natural that we should look into these systems in our efforts to explain why the rock breaks in a prescribed line. Good and true breaks have been made by Lewising, yet there is no V-shaped groove. Equally clear and efficient is the record of the old Portland canister, yet here, too, there are no V-shaped grooves. It might be argued that the Portland canister being embedded in sand or other non-elastic material forms a "wedge-shaped space," and here, too, quoting Mr. Knox, "the gas is forced into two opposite 'wedge-shaped spaces,' and the impact being instantaneous, the effect is precisely similar to that of two solid wedges driven from the center by a force equally prompt and energetic."

But we are met by the evidence of the Lewis hole, where there is no "wedge-shaped space."

While it is doubtless true that the "wedge-shaped space" is an influence which assists the break, and that the breaking of the arch of the hole by the groove renders equally great assistance in that it produces a weak point to start the break, yet the main cause in the Knox blast which acts to direct the break is that the lines of force are exerted against the surfaces of the hole A *b* B and A *a* B to a greater extent than upon the surfaces *a* A *b* and *a* B *b*. In other words, there is a greater area of pressure acting upon the surfaces *a* and *b*, and this naturally tends to produce a separation at A and B. The tension is precisely the same as that produced by a line of plugs and feathers, or by a series of wedges driven in a trench.

Let us assume that an effort was made to split by the Knox holes without an explosion, but by using hydraulic or other pressure within the holes. It is obvious that, were we able to get the pressure high enough, the break would be made in the same way as though it were blasted, and the very purpose of the air cushion in the Knox system is to prevent the shock of the blast from having a bad effect upon the rock, and to confine the gas and air at a high pressure in the hole. The suddenness of the explosion is relieved by an expansion and compression of the air cushion, and it is the recoil of the energy after such compression which exercises the greatest force in breaking the rock. Notwithstanding the cushion there is some shock, and this so far assists the break as to enable the operator to use but little explosive. Were the force exerted through hydraulic pressure, it would be advisable to produce a shock just as a quarryman will strike a block of granite with a heavy sledge in order to start the break while his plugs and feathers are under strain.

The Knox hole is, therefore, almost identical in principle with the old Portland canister, except that it has the great advantage of the V-shaped groove in the rock, which serves as a *starting point* for the break. It is also more than the Portland canister in that it *requires less drilling*, and the *waste of stone is less*. It is, therefore, not only more economical than any other system of blasting, but it is *more certain*, and in this respect it is vastly superior to any other blasting system, because stone is valuable, and anything which adds to the certainty of the break also adds to the profit of the quarryman.

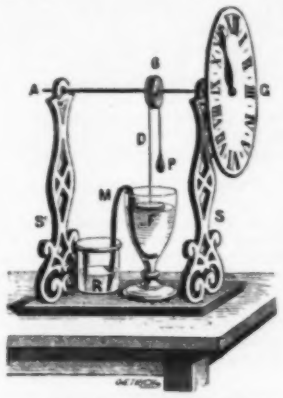
It is doubtless true that, notwithstanding the greater area of pressure in a Knox hole, the break would not invariably follow the prescribed line but for the V-shaped groove which virtually starts it. A bolt when strained will break in the thread whether this be the smallest section or not, because the thread is a starting point for the break. A rod of glass is broken with a slight jar, provided a groove has been filed in its surface. Numerous other instances might be cited to prove the value of the groove. Elasticity in rock is a pronounced feature, which varies to a greater or less extent, but is always more or less present. A sand-

stone has recently been found which possesses the property of elasticity to such an extent that it may be bent like a piece of steel. When a blast is made in the Knox hole, the stone is under high tension, and being elastic it will naturally pull apart on such lines of weakness as grooves, especially when they are made, as is usually the case in the Knox system, in a direction at right angles with the lines of least resistance.

Horizontal holes are frequently put in and artificial beds made by "lofting." In such cases where the rock has a "rift" parallel with the bed, one hole about half way through is sufficient for a block about 15 ft. square, but in "liver" rock the holes must be drilled nearly through the block and the size of the block first reduced.—*Stone.*

A SIMPLE CLEPSYDRA.

THE accompanying figure represents a little apparatus which we recommend to amateurs of ingenious constructions. The following is a description of its parts: A is an arbor resting upon two supports, S S (a knitting needle will answer very well, provided it is straight), and which carries at one of its extremities an



A SIMPLE CLEPSYDRA.

hour hand (a small clock hand) that revolves around a dial, C. To the center of the arbor is fixed a pulley, B, with a deep groove, over which runs a thread, D, to one of the extremities of which is attached a cork float, F, and to the other a counterpoise, P. At M an ordinary cotton wick, starting from the bottom of a cylindro-conical glass, falls into a receptacle very close by. After the large glass has been filled with water, the hand is placed upon the hour, the wick siphons the water and causes it to flow by degrees, and the float gradually lowering brings about a revolution of the hand. It is necessary to regulate the clock thus constructed. If it goes too fast, the thickness of the siphon formed by the cotton wick must be diminished. If it goes too slow, the thickness of the wick must be increased. The form of the cylindro-conical glass, upon which the regular running of this clock is based, was determined by Mr. Pellat, Fellow of the University, Doctor of Sciences, etc., of Paris; but after a few tentatives, one may succeed in constructing it by means of an ordinary goblet. —*La Nature.*

THE PARISE PIANOGRAPH.

NUMEROUS attempts have already been made to inscribe music by means of the keys of the piano upon which one plays, and a few years ago we gave a description of an apparatus devised by Mr. Carpentier, and which operated according to this principle. The apparatus was designed to prepare the music of the cards of his melotrope. It did not print in ordinary characters, but in lines of varying length designed to show where and how the holes in the card should be cut. Mr. Parise, whose system we shall now describe, has had another object in view, that of causing the piano to write in the usual characters, that is to say, with notes placed upon the five lines of the musical staff, and that too for all the octaves that the instrument admits of; so that a composer may be able to read his improvisation as soon as he has played it, or

FIG. 1.—PARISE'S PIANOGRAPH ADAPTED TO AN ORDINARY PIANO.

that it may be read by a person somewhat skilled in music.

Without any desire to discuss the necessity of such an instrument, we may nevertheless remark that the solution of the problem must present a certain interest, to judge from the numerous tentatives made in this direction since the invention of the harpsichord. Let us recall a few of these as a matter of curiosity. Creed, an English ecclesiastic, speaks of them as early as 1747, in the Philosophical Transactions, but he describes no apparatus. Two years later (in 1749), Unger, a German scientist, gave a plan of an apparatus which he presented to the Berlin Academy, and, toward the same epoch, Hohlfeld, another German, endeavored, but without result, to construct an analogous machine. In 1770, a mechanic of London, of the name of Merlin, constructed a machine for writing music, which was sold to Prince Galitzine. In 1775, Father Engramel, the author of a work on the art of pricking the notes of music boxes, appears to have solved the question, but no traces of his invention are extant. The public journals have on several occasions called attention to tentatives of the same kind, especially by Gattog (1783),

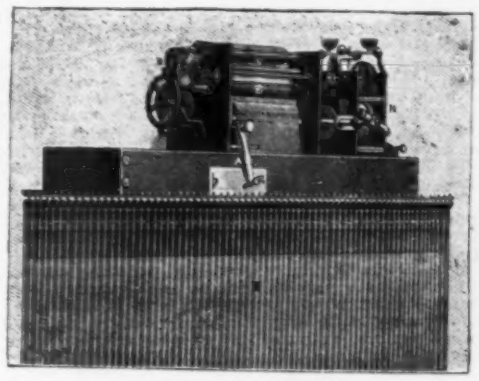


FIG. 2.—DETAILS OF THE MECHANISM OF THE PIANOGRAPH.

Heiffer (1801), Guerin (1844) and Mazzolo (1861), but none of these gave any practical results. It was not till the Vienna Exhibition of 1873 that was observed in operation for the first time a pianograph that truly merited the name. This was invented by Count Roncalli, an Italian engineer. It turned electro-chemical action to account and printed the tones, half tones, etc., in signs of different colors. It was a marvel of ingenuity, but by that very fact the instrument was too complicated and too expensive to be put into the hands of everybody, and it had no success. Still other apparatus have been constructed since, or at least have been noticed in the newspapers, but, aside from Mr. Carpentier's, spoken of above, and which operates very well for the special object in view, none has given practical results.

Mr. Parise's apparatus, which may be seen in operation at this moment at the Exposition of the Palace of Industry, is adaptable to an ordinary piano (Fig. 1). It consists of a series of levers, B, united upon two rods. These bear against the extremity of the black and white keys of the keyboard, A. At the upper part, that is to say, at the top of the piano, these levers are bent horizontally and engage in the box, C, where their extremities are aligned in a very small space.

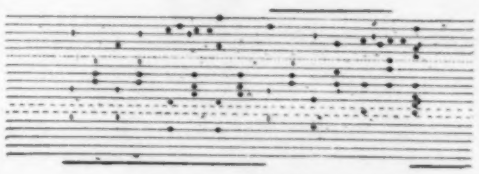


FIG. 3.—SPECIMEN OF THE REGISTERING OF THE INSTRUMENT.

Above these extremities rest small vertical rods which are very close to one another and end under the cylinder, E (Fig. 2). In other words, the rods, B, as a whole, are brought together in a smaller space in such a way as to rest beneath the cylinder, E.

It results from the arrangement of the levers that as soon as a key of the piano is depressed one of the small rods strikes the cylinder, E, and then immediately falls. A roll of white paper is placed in the apparatus and is carried along in a uniform motion by two cylinders driven by the clockwork, H, and a series of gearings, D. This paper (not represented in the figure) passes between the cylinder, E, and the levers which end there. It will hence be understood that if the extremities of the latter are properly inked they will form a dot upon the paper at every note touched. These extremities terminate in a point for the white keys and in a short line or dash for the black ones. The inking is done, as in writing machines, by means of an endless ribbon charged with aniline color.

Let us now see what takes place when the piano is

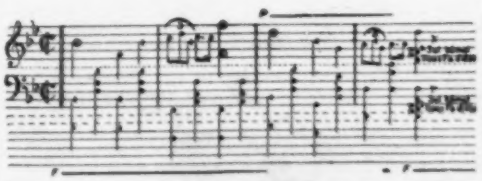



FIG. 4.—THE SAME FIGURE ANNOTATED BY THE COMPOSER.

used. If the fingers be passed over the white keys from one end of the instrument to the other, we shall obtain a series of dots (or notes, we ought to say) occupying the entire width of the paper and forming a line at right angles with its edges. But if the paper has a uniform motion and we again begin the same exercise, our series of notes will be inscribed in taking, with respect to the edges of the paper band, an inclination which will be inversely proportional to the speed with which the finger has been passed over the keyboard. At the same time, the space between each note will increase so much the more in proportion as the speed is slower. It will be seen from this that it is possible to obtain cognizance of the *value* of the notes by the space that separates them. The semi-breves will be followed by quite a wide space, the minims by less, the quavers and crochets by less and less space, and the demi-semi-quavers will nearly touch each other. The example that we present to our readers will allow them to see how the apparatus operates. Fig. 3 represents the paper as it appears after the execution of a few bars of the *Marche de Faust*. In Fig. 4 we have added the stems to the notes, and have indicated the minims, quavers and measure bars in ordinary writing.

In order to complete our description, we must add that the paper, after receiving the impression of the notes in black, passes beneath a roller, V (Fig. 2), which traces thereon the musical staffs in red. It is a question now of being able to write in sharp or flat. To this effect, the apparatus is provided with a lever, A, which may be moved to the right or left and be placed either upon the sharp or the flat sign, according as one writes in sharp or flat. The crotchet notes, as we have said, are printed in a small vertical dash, which will always be found in the place of the flat or sharp note according as the lever of the pianograph is upon the flat or sharp sign. Thus *mi* sharp, or *si* sharp, is inscribed in a vertical dash on the line of *fa* natural and of *do* natural, but, in a vertical dash instead of a round dot. The pedals also are indicated—the *piano* pedal by a continuous line on one of the edges of the paper, and the *forte* on the other edge.

The apparatus may likewise serve to transpose a *morceau* once for all and to preserve a draught of it in the different tones in which one wishes to have it.

We do not pretend that a person, even a musician, could, at first sight, play the manuscript (or rather the *pianoscript*) which comes from the instrument. As with everything else, a little study is required, but we think such study would be easily done and would prove useful to a person who desired to preserve a copy of his improvisations.—*La Nature.*

A NEW PROCESS FOR PROTECTING IRON AND STEEL.

WE briefly mentioned recently a process known as the electro-lead process. We may now add a few particulars. The covering metal used, unlike the old processes of the kind, is lead instead of an alloy of lead and tin as in terne plating, or zinc as in ordinary galvanizing, than on any essential connection with electricity, the sole cause for appending the term "electro" to its title being the subjection of the plates before dipping to the action of a pickling bath in which their cleansing is aided by the use of a weak current of electricity.

The process, as carried out at the works of Messrs. Joseph Westwood & Co., at Millwall, consists essentially in treating the materials to be coated in a pickling bath containing about 10 per cent. of hydrochloric acid and 1 per cent. of hydrofluoric acid at a temperature of 120° Fah., transferring thence to a tank of lime water at the same temperature, and thence to a solution of stannous chloride and zinc chloride, also kept warm, and finally to a bath of metallic lead in which they are dipped or through which they are run, thus receiving a coating of the fused metal, sufficient, it is said, for their protection. The electrolytic treatment is confined to the first or pickling bath, and its value appears to be rather confined to hastening the cleansing process than to bringing about any result that could not have been attained by purely chemical means. A coil of wire netting was selected for experiment at the time of the visit of our representative, and its coating was effected in a very complete manner.

Plates were also covered by simple dipping with similar success. It may, therefore, be conceded that by the aid of the careful pickling we have described—whether or no it depends in any sense on the employment of electrolytic cleansing—it is possible to cover iron and steel completely with lead. This is a step of considerable technical importance, as the attainment of an adhesive film upon iron or steel has been until lately a matter of some difficulty. That the adhesion of the lead to the iron is very considerable is proved by various tests of the coated articles that have been made. Sheet and bar metal can be bent and twisted after coating without causing the lead to exfoliate in the manner familiar to the users of galvanized goods. The known ductility of lead forbids the supposition that the coating would crack locally when thus treated.

In point of cost, the process compares favorably with galvanizing, for several reasons. In the first place, the price of zinc is about double that of lead; secondly, the weight of the coating is stated to be only about one-half that needed in ordinary galvanizing; thirdly, the masses of zinc iron alloy which form at the bottom of galvanizing baths are, of course, absent when lead is used; fourthly, the baths themselves are not attacked by the melted metal, and their destruction can only result from their being burnt out by the furnace beneath, instead of occurring inevitably from the action of the metal within. Some tests have been made of various articles coated by the new process, the results of which are interesting, as showing its capabilities. Thus it is stated that small iron bars breaking at 26 tons per square inch broke at 24 tons when galvanized, while showing no such reduction of strength when lead coated. Sheet iron coated and bent double remained free from cracks, and the coating on the rivets, the heads of which had been squeezed flat or otherwise defaced, was similarly intact. Staples coated with lead showed a similar superiority to those galvanized, withstanding the test of opening them out flat with greater certainty than did those covered with zinc. Nuts and bolts, wires, telegraph posts, acid tanks, gas and water pipes, and many other articles are susceptible of treatment by the new process.

The capabilities of the process in these respects having been demonstrated, there remains for consideration the important question of the efficiency of the covering for the protection of the metal beneath it. As we pointed out the other day when describing another process of similar character, the known excellence of zinc, and the preference that is rightly given it over tin when a covering of real permanence is re-

quired, depend upon the elementary electro-chemical fact that zinc is electro-positive to iron. Although, therefore, zinc is liable to strip from galvanized articles, the bare places are less liable to corrosion than they would be were the surrounding coating absent, precisely the reverse being true in the case of tin. Lead holds an intermediate position in this respect, and the point of supreme importance to be settled before any lead covering process can be accepted as replacing galvanizing in all its developments is the question as to how far such corrosion may be expected to take place. The softness of lead is a property which is at once favorable and inimical to the permanency of a coating consisting wholly or mainly of it. On the one hand, as has been shown, it has little tendency to scale; on the other, it is readily removed by abrasion. As long as the coating remains intact, the chemical inertia of lead will permit it to present an excellent front to the attacks of a corrosive agent; but when once the coating is destroyed at any given spot, that very chemical indifference will cause it to form the negative element of the couple, consisting of itself and the iron it is supposed to protect, and enhance by its presence the attack of the latter. How far this action will be of practical importance depends greatly upon the perfection of the adherence of the lead to the iron. Corrosion which is strictly local, although far from desirable, is of much less moment than that which, starting from a given spot, spreads beneath the film of protecting metal, and continues its attack the more dangerously because unperceived.

A priori opinions are of little value in a case such as this; the matter is eminently one for direct experiment. Had adequate attention been paid when the several lead processes, of which this is a type, were conceived and afterward put upon a semi-commercial footing, to the chemical as distinct from the engineering aspect of the question, the solution of this possible difficulty would have been already reached. Should those responsible for the exploitation of the new method satisfactorily prove that the trouble we have indicated is of smaller magnitude than at present appears, or can be overcome by some simple means, they will confer a boon upon the manufacturing community, and, no doubt, reap a sufficient reward themselves.—*The Engineer.*

PAINTS—THEIR COMPOSITION AND PURITY.*

As showing the inadvisability of using inferior qualities of paint the following illustration gives in a concise manner the reasons for improvement in this department of car manufacture, especially when one considers that one of the main objects of paint is the preservation of the material over which it is spread.

Suppose a small depot along the line requires 20 galls. of paint. If the material selected for this work was cheap, 75 cents per gallon, the cost would be $15; cost of application, $25, making a total cost of $40. Such a paint would last almost two years, or a cost of $20 per year for this station.

Now suppose the material selected for this station was the best paint. Twenty gallons would cost, at $1.50 per gallon, $30; the cost of application the same as that of the cheap material, $25, making a total cost for the best paint of $55. Suppose it lasts but three years, we would have a cost of $18.33 per annum for good paint and $20 per annum for cheap paint.

What, therefore, becomes the main safeguard for that all-important quality, durability? The use of that which thus far has proved most effective against the elements—pure linseed oil. That is the life of a paint and cannot be supplanted by fish oil, resin oil, emulsions, soap mixtures and the like.

At this stage the question as to the advisability of the use of ready mixed paints may be out of place, but the paints are worthy of a passing notice.

Very often painters encounter streaked jobs, not to speak of the many other ills. This in many cases is due to the fact that without the proper facilities, even with the utmost care exercised, the coloring pigment is not sufficiently or properly incorporated with the base. This most desirable feature is and can only be obtained by proper and specially constructed machinery.

As to coach colors, or more properly passenger car body or truck colors, more than the ordinary care in selection must be exercised, for if the vehicle employed in them is defective even to the smallest degree, all that covers these colors, such as rubbing and finishing varnishes, is lost, and these are but small items compared with the heavy cost of experimenting, applying labor, etc. How much more will a car cost finished with the best make over one done with the cheapest material? Is a consumer warranted, for the sake of a few pennies, incurring the above mentioned heavy costs?

The next important feature in a paint or color is its beauty—its brilliancy; the next vital point is strength or covering capacity.

Many manufacturers place their entire force on the strength of their products, but either evade or lose sight of the fact that brilliancy of color or the productions of fine, soft, true tints is what the consumer wants. To use a strikingly forcible illustration, test, for instance, the Prussian blues. Some with white will produce a rich sky blue tint, while others will show a decided dull blue or gray lampblack effect. The latter article will unquestionably stain more white.

Another important feature in paint is physical, *i. e.*, the consistency. A color that is ground stiff and in paste form is cheaper than the semi-liquid. The best way to understand this is by calculation.

Say a pound of car body color in good paste form costs 25 cents; compare this with an article that is semi-liquid and costs but 22 cents. To the former you can add ¼ lb. turpentine at a cost of 1½ cents, and make an article identical in consistency with the semi-liquid, and have 1¼ lb. of paint at 26½ cents, or 21⅓ cents per lb., or a saving of 0·8 cent per lb.

Does this not establish the fact then that that material, so ground, that will permit the introduction of turpentine, when the color is in the hand of the master painter, is a superior, more desirable article than that whose consistency, in semi-liquid, deprives the color of this necessary feature? You pay for turpentine in a semi-liquid color, and are compelled to work the color over after all, when in a pound of car body color in good paste form you introduce the turpentine as the color may require, thereby reducing the cost, as your color increases in quantity.

As the last but not least of all the durable features in paint appears "fineness of grinding." The advantages and economy of correctly ground paint are so striking that little need be said. We all know that a weaker pigment finely divided or ground is rendered as effective in covering capacity as a coarse ground article.

* Extracts from a paper read before the Northwest Railroad Club, by J. P. Seymour.

MONUMENT TO PIERRE FONTAINE AT ANZIN.

A MONUMENT to a simple laborer! Such a thing is so rare that it gives us pleasure to make a note of it and to congratulate the municipal council which took the initiative in it. This laborer, whose bust will soon be placed in one of the squares of Anzin, is Pierre Joseph Fontaine, the inventor of the safety apparatus for mine cages, and whose life was really remarkable. He started in one of the pits of the Anzin concession and became a miner and afterward an overman. As brave as he was intelligent, he one day, in trying to save life, during a fire, received an injury that rendered him a cripple for the rest of his life.

The company, in consequence of this act of bravery, appointed him foreman of the workshop. He could scarcely read, but his new position allowed him to study, to make researches and to invent.

It was thus that he was enabled to bring out his famous safety apparatus for mine cages, thereby suppressing the labor of descending and ascending by ladder, while at the same time preserving his comrades from a terrible fall to the bottom of the shaft. Thousands of miners have been, and are still being, saved through this apparatus.

MONUMENT TO PIERRE FONTAINE, AT ANZIN.

This invention gained for the modest workman the highest rewards, and, among others, the Monthyon prize and the cross of the Legion of Honor.

Fontaine's bust will be executed by Mr. Theunissen, a young statuary of Anzin, and will be placed upon a pedestal in the center of the square of the Ancienne Mairie.—*L'Illustration.*

ELECTRICITY IN THE PRESSROOM.

THE following paper, on "Electricity in the Pressroom," was read by Mr. Crutsinger, of St. Louis, at the recent session of the United Typothetæ of America. It will repay perusal:

The subject of "Electricity in the Pressroom," or, rather, in the sheets as they pass through the press, is one which has engaged the attention of scientific men, and at times, ever since the advent of the present style of heavily sized and highly calendered papers, has nearly worried the life out of practical printers.

Judging by the heavy sprinkling of gray hair among the members here present, there are many who, like myself, remember well the time when soft rag paper, *properly dampened*, was used on book and catalogue work there was no such thing as electricity on the press thought of.

That electricity does exist on the press now is a fixed and often a very disagreeable and unprofitable fact.

How electricity gets into the paper probably does not interest us so much as does how to get rid of it, yet it might be well to say something about how it gets there.

The text books tell us that electricity is excited or generated by friction, change of temperature or chemical decomposition.

It is generally conceded that the pressure and friction of the calendering rolls through which the paper passes in the machine, during the process of manufacture, are responsible for the generation of the electricity in it. I am informed that the "lay boys," who are usually girls, and the last handlers of the paper before being tied up into bundles, are often overcome by the amount of electricity absorbed into their systems from the paper, and but few of them are able to remain on duty for more than a couple of hours at a time.

But you will say that not all the highly finished papers, as they come from the mill, are so charged; that which we get in summer being rarely so charged, while that which is made in winter is very often so affected; consequently we are led to believe that the conditions existing in winter are more favorable to the production and bottling, as it were, of electricity in the paper than are the conditions which exist in summer.

In winter, with the temperature around zero, the atmosphere is as nearly dry as it ever gets to be, as the moisture is then congealed and deposited in the shape of frost and snow.

In summer, the air is, during the driest weather we have in this latitude, only comparatively dry.

Air charged with moisture, especially warm air, is an excellent conductor of electricity, while dry air is the reverse.

If you will look into this matter, I think you will find that nearly if not all papers in original packages which are electrified will be found to have been made in cold, dry weather. There may be a few days in summer sufficiently dry to produce the same effect, but not many.

When the atmosphere is moist, it carries the electricity off from the paper as generated; and when it is dry, at least a part of the electricity generated is left in the paper.

Again, we find that papers which have exhibited no sign of being electrified, in the original package, and which behave in the most circumspect manner while going through the press on the first side, will, on running it through to print the reverse side, become highly electrified. Some sheets will come back with the fly, while others will shoot under the press and scatter over the floor on all sides of the fly table. That this is caused by electricity is easily proved by bringing the knuckle or a piece of blunt metal in close proximity to any metallic part of the jogger, when a spark will be obtained.

In this case there is little or no electricity apparent in the paper when put up on the feed board. Going through the press to be printed on the first side seems to slightly charge it, and it is still further charged by passing through the press to print the second side, rubbing on the sheet below, and on the metal-clad edge of the feedboard, and on the fenders.

We find in the printing office that this condition occurs chiefly in winter, when the weather outside is clear and cold, and the atmosphere dry, and communication between the atmosphere of the pressroom and the outside is shut off by closed doors and windows. It is much more likely to occur in steam-heated pressrooms, where proper attention is not paid to ventilation, causing a hot, dry air, than in rooms heated by stoves, where the ventilation is much better.

There have been a number of mechanical devices invented for the purpose of overcoming or getting rid of this very annoying and expensive trouble. None of them have been, as far as I know, thoroughly satisfactory. What would produce good results in one office would be found almost, if not quite, valueless in another, and it appears no mechanism can be devised for overcoming the difficulty, on account of the very great differences in conditions existing in the different pressrooms.

It may be observed that electricians are not devoting their time and inventive talent to devising methods whereby they may dissipate or get rid of electricity, but rather to holding it for use. They are bending their energies to devise new and better methods of insulation, so that the electricity, which costs them so much to generate, shall not leak out from their wires and dissipate itself in the air and ground. They find, in practice, that close proximity to a metal down-spout or front of building will oftentimes cause a leak which is hard to find and remedy; and a wet or ice-covered insulator may render a circuit wholly unserviceable.

Then why should not printers take advantage of this propensity which electricity has for getting away? It is in the paper, but will not stay there if a good opportunity is given it to get out.

We find, in practice, that damp paper is never electrified. We find again, in practice, that during the summer, when the atmosphere is comparatively damp, and the communication between the air of the pressroom and the outside atmosphere is unobstructed by closed doors and windows, we have little annoyance with electricity.

We find the trouble to be serious *only* in the winter, when the atmosphere is more nearly dry than at any other time, and the communication between the atmosphere of the pressroom and the outside is cut off by closed doors and windows, and that the worst trouble is found in ill ventilated steam and furnace heated pressrooms, where the air is dry and parched.

Now, if we have no trouble in summer, and do have trouble in winter, is it not reasonable to suppose that if we produce the same atmospheric conditions in our pressrooms artificially, during the winter, that exist naturally during the summer, and pay more attention to proper ventilation, we will get rid entirely of this trouble and annoyance?

This, gentlemen, is my suggestion. There are those present who have given it a fair trial, and will, no doubt, be willing to give us the benefit of their experience.

Mr. Crutsinger's paper was followed by that of Mr. Moorehouse on the same subject. He said:

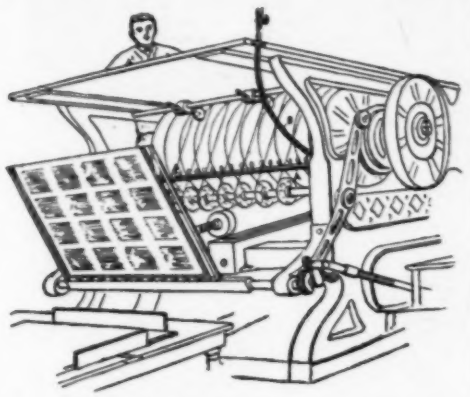
The able treatise on electricity, in the paper which has been read in your hearing by Mr. Crutsinger, has told us of all the annoyances with which we are troubled from the highly calendered paper now in constant use on our modern book and job cylinder presses, but no sure remedy has been suggested for the evil.

For the past three years the firm with which I have the pleasure to be connected has applied a series of gas jets behind the fly, as shown in the sketch accompanying, and has found entire relief from the electricity, and very great gain in the drying of fine ink on illustrated work, where formerly "slip sheets" were required.

This imperfect pen sketch may represent the rest

end of a drum cylinder press, or the delivery cylinder of a two-revolution press. The rod, A A, is a copper gas pipe, three-eighths of an inch in diameter, with holes perforated on the top, one and one-half inches apart. The holes should be of such a size as to permit the flame to be about one and one-quarter inches in height with a full pressure of gas on the pipes.

The gas pipe is suspended at the ends with flat hooks attached to the side frames of the press and connected at one end with a small rubber gas tube, B, and this tube is fastened at the upper end to an iron gas pipe with a stopcock attached. In this manner the rubber tube can be detached, and the copper gas pipe easily removed, if required. Care must be used to place the gas pipe at such a distance from the delivery cords or tapes, and from the fly while in position to receive the printed sheet, as not to endanger burning them. Rarely will the full pressure of the gas be found necessary to accomplish the warming and drying of the paper enough to overcome all electricity, or to insure the sheets from "setting off" in work where a large quantity of ink seems necessary.



Formerly, and for several years, steam was applied by us in the same manner as now suggested for gas, with excellent results so far as the printing was concerned. The objections were the rusting of the bright parts of the press, and when several presses were in use with the steam at the same time, the air of the room was injurious to the throats of the workmen. By the use of the gas these troubles are avoided.

The expense of fitting a press with this appliance is very trifling, and the experiment well worth a trial.—*The Artist Printer.*

THE DYNAMOS AT FRANKFORT EXHIBITION.

By W. B. ESSON.

THE Maschinenfabrik, Esslingen, exhibited an eight pole 60 kilowatt dynamo. This machine is coupled direct to a horizontal compound engine, and gives, at a speed of 100 revolutions per minute, a current of 124 amperes, at a difference of potential of 480 volts. The armature is 114 cm. in diameter, and has a drum winding, there being 694 conductors on its exterior, counted all round the periphery. The armature core is built up of iron plates, 1 mm. thick, separated from each other by paper, and the whole is supported by a strong cast iron center piece, keyed to the engine crank shaft. The commutator has 347 segments, insulated with mica, and the ring carrying it is secured to the armature casting above mentioned. In connection with the commutator, it should be mentioned that this machine is quite exceptional in having mica between the segments, the insulation used almost universally for German machines being of "presspahn," or cardboard made from wood pulp. The radial magnets are cast in one with the octagonal frame which supports them, the latter being jointed vertically, as shown. Two sets of brushes, at 45° angular distance apart, collect the current which flows through the 694 conductors in two parallels. The engine cylinders are 32·5 cm. and 50 cm. diameter, respectively, and the stroke is 60 cm. The working pressure is 8 atmospheres, and the steam is admitted by double beat valves in conjunction with trip gear, the point of cut-off being controlled by the governor. The combination exhibited gives for each kilogramme of steam a return of 71 watt hours with, and 52 watt hours without, a condenser, the exhibitors stating that their object has been, not to get a dynamo which does a large quantity of work for its weight,

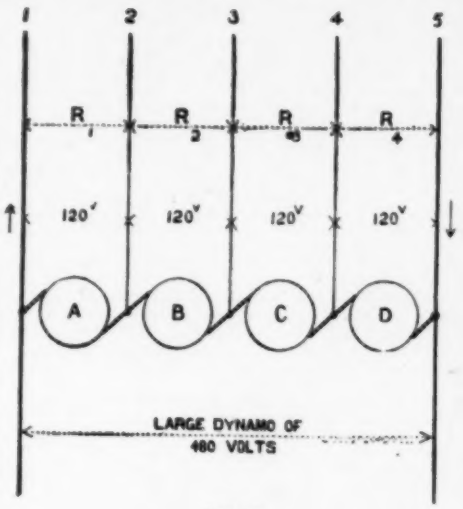


FIG. 2.

but one from which is obtained the highest electrical return for the consumption of a given quantity of fuel.

The machine above described is shunt wound, and supplies current through a five-way system of distribution. The two outside conductors of the system are connected to the machine terminals, while the three intermediate conductors are connected up to a compensating motor dynamo. This compensator consists of the machine illustrated in Fig. 1, which has an armature Gramme wound, with four distinct circuits connected up to four separate commutators. The magnet winding is a shunt to the two outside wires and the excitation is consequently constant, due to a potential of 480 volts. It will be seen from the diagram of connections, Fig. 2, that all the commutators are joined in series, the first and fifth conductors being connected outside the two extreme ones, and the second, third, and fourth between consecutive ones. When all the four circuits take through R_1, R_2, R_3, and R_4, the same current, the motor dynamo is driven by a small current flowing through the four armature windings, A, B, C, and D, in the same direction. If in one of the branches, say R_3, the resistance is increased, the difference of potential between the two conductors, 2 and 3, rises by a very small amount, while in the other branches it falls. The consequence is that, while the armature increases in speed a little, the winding, B, between the wires 2 and 3, receiving current and acting as a motor, the other three windings, A, C, and D, are acting as generators, the current now flowing in an opposite direction through them and an E.M.F. being added to the circuits, R_1, R_2, and R_4, with which they are connected. The compensator in this way keeps the difference of potential for each circuit constant, always running as a motor and taking power from the least loaded circuits, to give it back, acting as a generator, and raising the potential of the circuits loaded more heavily. The writer is assured that the compensator acted most efficiently, the four voltmeters in the branches showing no perceptible deviation from 120 volts.

Current may be taken direct from the terminals of the machine at 480 volts, or, if desired, from the middle wire and one outside one at 240 volts. At the former pressure it was supplied to the 50 horse power four-pole motor used to pump the water from the Main quay to the lake in the Exhibition grounds, and for this purpose the dynamo had to run nearly all day, as the water was used for condensation in several steam engines. The other electromotors coupled to the system were supplied with current at 120 volts, as were also all the arc and glow lamp circuits.—*Electrical Review.*

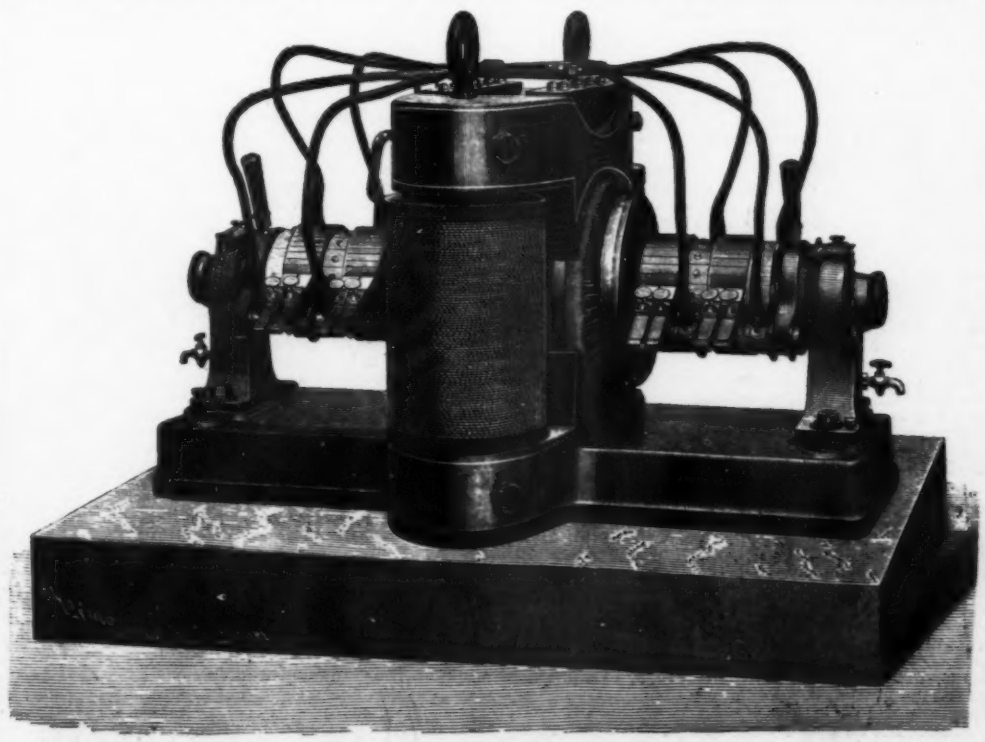


FIG. 1.—THE COMPENSATOR.

LONG DISTANCE TELEPHONY.

By G. L. D.

THE introduction of long distance telephone lines in this country has been accomplished with so little talk, that most people believe that the connection between places often hundreds of miles apart is effected by the mere extension of local wires, and the use thereon of instruments in all respects similar to those used in communicating with parties a few blocks away. They are not aware that the success of the longer lines is founded entirely upon a single patent, for the powdered carbon transmitter, which was granted to Webster Gillette in March, 1879.

The inventor began his electrical work in 1853, when he took charge of the first telegraph line in the State of Michigan, which connected the towns of Ypsilanti and Wayne. He was then in his teens, and it was not until he was 20 years old that he began to study electricity in earnest. He was fortunate in obtaining his early experience with Dr. Hill, of Chicago, who, noting his aptitude for the work, took great interest in his instruction.

One of the first inventions he made was a device to do away with relay stations on long telegraph circuits, for which he was offered a large sum. Later he patented an electric temperature signal, to give notice of a dangerous rise in the temperature in large bins of grain, elevators, malt houses, dryrooms, ovens, etc., which proved a very useful and valuable invention.

His attention was early directed to telephony, and having become thoroughly conversant with the peculiar qualities of powdered carbon in his experiments in former years, it was natural that when he began his researches in this field, in 1876, he should make use of it for the variable resistance he required.

The first practical demonstration of the real utility of his long distance instruments was made in the year 1879, over the wires of the American Union Telegraph Company, between New York city and Philadelphia. Mr. Gillette's next trial worthy of mention was between Elmira, N. Y., and New York city, a distance of 270 miles. A full account of this test was published in the Elmira *Daily Advertiser* of January 23, 1884. Other tests followed, among them being one from Meadville, Pa., to New York city, a distance of 509 miles; one from Cleveland, O., to New York city, over 631 miles of wire; and still another from Chicago to New York, the length of wire being 1,010 miles.

These several tests are believed to be the first successful exhibitions of long distance telephoning the world had had. Several inventors had tested long distance instruments of their invention, but none, so far as is recollected, succeeded to any degree unless they used powdered carbon instead of solid carbon for their variable resistance. The invention of Henry Hunning, one of the earliest in this field, used powdered carbon, but proved to be impracticable for general use, because the powdered carbon was in a loose state and required to be "shaken down" at short intervals. Mr. Hunning filed his application in the United States Patent Office, September 30, 1881, and received his patent November 29, following. It will thus be seen that Mr. Gillette's patent antedated it by nearly two years, having been filed November 27, 1878, and being issued March 18, 1879. In his specifications Mr. Gillette stated that the carbon should be slightly compressed.

On April 17, 1880, Mr. Gillette entered into contract with the American Union Telegraph Company. Very little had been published of the several tests that had been made of his invention. The test between New York and Philadelphia in 1879 was made for the benefit of the officials and stockholders of the American Union Telegraph Company, but only a verbal report was made by the expert as to the results. Later on fuller accounts of other tests were published. The Boston *Journal* of Feb. 4, 1884, and the Boston *Globe* of March 3, 1884, each gave accounts of exhibition tests made about that time. The reports made by experts in regard to these patents were to the effect that they in no way interfered with the patents of Mr. Bell or others, and on the strength of these reports the American Union Telegraph Company took up with Mr. Gillette's invention.

When the American Union and the Western Union companies combined, February 13, 1881, all the patents and valuable franchises held by the American Union became the property of the Western Union, and in the bill of sale of the effects the patents of Webster Gillette are mentioned.

There is no evidence to show that the Western Union Company has transferred its title or interest in these patents to the Bell Telephone Company, but it is believed that no such formal transfer would be necessary, as it is understood that the existing contract between the Western Union and the Bell Telephone Company especially stipulates that all devices and appliances relating to telephony which the Western Union may acquire should be at the service of the Bell Company should it desire to use any of them. Mr. Gillette personally, it is said, never had any dealings with the Bell Company, although there is no doubt but that a strong effort was made on the part of the company in 1879 to secure control of his patents.

In May, 1885, Mr. Gillette was in Europe and telephoned the first hundred miles that was ever done there. The first test of consequence was from London to Carlisle, a distance of about 300 miles. The next test was over the Midland Railroad Company's lines from London to Derby. Later he made a test of underground lines in Paris by connecting several lines together, and over 116 miles of wire he secured results equal to what he had secured upon aerial lines. These

tests were a great surprise to the electricians of Europe, as there had been several attempts to accomplish the same results by other inventors, but without success. Another test that was made was from Paris to Nantes, a distance of about 328 miles.

Then followed the most startling and perhaps most important of all the experiments in this line that Mr. Gillette had made. This was from Dover, England, to Calais, France, over the 21 miles of cable across the channel, laid in 1853. No one believed that it would be possible to accomplish anything, because the cable was old and in a leaky condition. When the tests were made, however, a watch applied to the transmitter at either end was heard distinctly at the other end, and conversation was correspondingly successful. This test overthrew all the prevailing theories against transmission by cable, and the result was the construction of the present London-Paris telephone line. All the tests in France were carried on through the aid and patronage of the minister of telegraph.

There seems to be little doubt but that these were the first successful long distance tests of the telephone made in Europe, and that the success of the present lines there was due to these experiments and to the inventions of Mr. Gillette.

In 1884 Mr. Gillette believed that he could telephone from America to Europe by using one of the ocean cables and that it could be done practically as well as though there were only a single mile of wire. Nothing, however, of importance was done toward accomplishing this. Mr. Gillette is still alive and resides in New York city.—*Electrical Industries.*

THE PRESENT STATUS OF ALUMINUM.

By R. L. PACKARD.

UNTIL the last hundred and fifty years, it has not been the lot of persons who could record and publish the fact to witness the birth of a useful metal. If we could only know by what accident iron, for example, was first found by primitive barbarians to be a substance which could be obtained by smelting its ore, or how the first simple methods of extracting copper, tin, and lead were hit upon, the beginnings of all metallurgy would be revealed to us. But prehistoric oblivion has covered the origin of these early arts. The last half of the last century, however, and the first part of the present comprised a period in which many metals which are now well known were discovered and described. Among these was aluminum, a metal which has been attracting a great deal of attention in the technical and commercial worlds in the last few years. The present century witnessed the discovery and separation of this metal in the chemical laboratory, and the present generation has seen the laboratory processes reproduced on an industrial scale, so that a metal which was only a chemical curiosity forty years ago has now become, by the assiduous efforts of chemists and metallurgists, tolerably well known to the public, has been shown to have many uses in the arts, and is quoted in the markets along with other metals of daily use. Just at present, it must be confessed, the uses of the new metal are of a somewhat limited character, but its producers and advocates are full of hopes for its future.

The discovery of aluminum was made in the first third of the present century, an important period in the history of chemistry, which science—it was hardly a science then—was experiencing its share of the great intellectual activity which prevailed in Europe at the time. The field of investigation was still fresh and of unknown extent, and was fruitful in discoveries of the kind, which were, however, only a part of the general movement in chemistry when physical investigations were brought to the aid of that science, and the remarkable inductive generalizations were made that established many of the chemical theories which are now regarded as fundamental.

By the end of the last century it was known among chemists that what were called "bases" of the heavy metals, according to the dualistic views then prevalent, consist of a metal and oxygen, as copper oxide, for example, which is the "base" of copper salts, is a compound of copper and oxygen, or iron oxide which is the base of the salts of iron, is composed of metallic iron and oxygen, and so on. Analogy indicated that the alkaline earths baryta, strontia, and lime, which were recognized as bases, and those powerful bases, the caustic alkalies, might also be compounds of a metal and oxygen. This conjecture was proved to be true by the famous experiments of Sir Humphry Davy, who succeeded in obtaining the metals sodium and potassium from their oxides, the caustic alkalies soda and potash, and the metals barium, strontium, and calcium from their oxides, baryta, strontia, and lime, by the current from a powerful battery. His success with these refractory substances led him to operate in the same way upon alumina, which was also recognized as a base, with the hope of obtaining from it the metal which he had every reason to believe it contained. But his attempts in this direction were unsuccessful, although his experiments gave indications that this earth contained a metal. He therefore endeavored to decompose it by chemical means, by subjecting it to the action of potassium vapor at a high temperature, a process by which he had shortly before obtained the metal barium from baryta. But in this also he was unsuccessful.

These experiments of Sir H. Davy were made in 1807 and 1808, and although they did not clearly prove the existence of a metal in the earth alumina, yet they are interesting as the pioneers of the two lines of experiment—the electrical and the chemical—by each of which alumium was afterward obtained, and each of which led to the establishment of commercial processes for the production of the metal. In Germany, twenty years later, Wöhler obtained aluminum from its chloride, by acting upon that compound with potassium, in small porcelain crucibles, and this was the first time that the metal had ever been certainly seen and enough of it obtained to allow of its identification and description. Still later, in 1845, by varying the experiment somewhat, Wöhler obtained the metal in larger quantities and gave a further account of its properties.

The substitution of the chloride of aluminum for the oxide in this operation was the cause of Wöhler's success, for the reason, which is now well understood, that while the heat of formation of chloride of potassium is greater than that of chloride of aluminum, so that potassium can displace aluminum from its chloride, the same cannot be said of the oxides of the two metals.

These laboratory experiments of Wöhler's were resumed in France by H. Sainte-Claire Deville in 1854. He conducted his operations on a larger scale than Wöhler, and substituted the cheaper sodium for potassium to displace aluminum from its chloride. In detail his method, which followed Wöhler's later experiment, was to place the aluminum chloride in a glass tube through which some inert gas could be passed, and introduce little porcelain trays containing sodium into the tube near it. On heating the tube the chloride was volatilized, and coming in contact with the sodium, which was melted by the heat, was decomposed by it, metallic aluminum being set free, while double chloride of aluminum and sodium was formed, which retained the aluminum in a finely divided state. This mixture was afterward placed in small trays of retort carbon, which were highly heated in a porcelain tube through which a current of dry hydrogen was passed, and the double chloride was driven off by this means, leaving the aluminum to be subsequently remelted and run into ingots. This laboratory process Deville reproduced on the large scale in 1855, replacing the laboratory apparatus by a retort for volatilizing the double chloride of sodium and aluminum (which he used instead of chloride of aluminum alone), a chamber connected therewith containing iron nails to retain any iron chloride that might pass over with the other chloride, and beyond this a third chamber containing trays of sodium, the whole being suitably heated. This arrangement being found unsuitable, the inventor, after patient experiments and various changes, modified his process so that the double chloride was made in a separate apparatus by passing chlorine gas through a highly heated mixture of carbon, alumina, and common salt contained in a retort, whereby the double chloride was formed and volatilized, while it was collected in a suitable receiver. It was then melted on the hearth of a reverberatory furnace, fluorspar or cryolite was added as a flux, and the proper quantity of sodium was added to separate the aluminum from its combination when it was removed from the furnace and cast into ingots. This describes the Deville process as it was in 1859. It was practically the only process employed in Europe down to three or four years ago. From time to time many improvements have been made in preparing the materials to be operated on and in lessening their cost, as was notably the case in the manufacture of sodium by the Castner process, which was established in England in 1888, but the metallurgy has remained substantially as it was when Deville completed the process over thirty years ago. The Emperor of the French generously supplied the funds for the various attempts which finally resulted in the satisfactory operation of the process on the large scale, and took a lively interest in what promised to be a successful business enterprise. The successive trials as described in Deville's book *De l'Aluminium* are very interesting, as they illustrate the progress step by step of a laboratory experiment toward a metallurgical process, guided by the hand of a master. It is for this reason that the foregoing technical details have been given somewhat fully.

The Deville process at the time its inventor completed it was at best a very expensive one, mainly on account of the high price of sodium, and although the increased demand for this metal caused by the new process led to its cheaper production, the price of aluminum in 1860 was still very high—300 francs a kilogramme—a price which precluded its commercial use except in a very small way, and its production was only at the rate of about a ton a year.

Aluminum had been shown as a curiosity as "silver from clay" at the Paris Exposition of 1855, where it appeared both in the form of ingots and of manufactured articles of various kinds in which lightness, resistance to corrosion, and strength are desired. Its use gradually extended for small articles having these properties and for parts of optical and mathematical instruments, and an English manufacture was started about 1860 which produced a considerable quantity of the metal for such purposes. But although the price had become reduced to 140 francs a kilogramme by 1867, or less than half the figure of 1860, it was still too high to allow of any extensive use of the metal. The report of the United States commissioners to the Paris Exposition of 1878 describes aluminum as shown in the form of blocks, wire, sheets and foil, and "objects from a thimble and a penholder to dinner sets of aluminum bronze and metal." Telescopes, opera glasses and other optical instruments, mounted wholly or in part of aluminum, and chemical balances made of the same metal, were shown which were very light and strong. If we add to this list that dental plates, parts of surgical instruments, chemical and druggists' weights, spoons, leaf for decorators, medals, fittings of various kinds, toilet articles, and, in short, an infinity of small things which are required to be light and strong and resist tarnish, were also made of aluminum, we get an idea of the narrow scope of the uses to which the metal was restricted down to four or five years ago. At this latter period its market price was as high as $1.25 an ounce which, of course, was prohibitory of its use in a large way, and its production did not much exceed two and a half tons a year.

Up to this time no aluminum had been produced in the United States, either as such or in the form of alloys, but in 1885 the production of aluminum alloys by electro-metallurgy was successfully inaugurated in this country, and this step was soon followed by the manufacture of aluminum itself by the same means. Without going into the history of this part of the subject too minutely it is sufficient to say that it follows the analogy of the history of the chemical process, and began with Sir Humphry Davy's failure to obtain aluminum from alumina (its oxide) by the galvanic current. Nearly fifty years later, Deville, guided by Professor Bunsen's experiments with magnesium chloride, from which he had obtained magnesium by electrolysis, operated upon his double chloride of aluminum and sodium while in a state of fusion by the same means and obtained aluminum from it. No attempt was made at that time to put this discovery to a practical use on account of the probable cost of the process and the technical difficulties in the way, which it would therefore not be worth while to try to overcome. But thirty years later, after dynamos had been introduced into the arts and found available for metallurgical purposes, the former objections to electro-metallurgy were no longer serious obstacles, and a new departure was taken with aluminum.

The first process of this kind to attract attention in this country was that of the Cowles Electric Smelting and Aluminum Company, which began its operations at Cleveland, Ohio, in 1885 (afterward removed to Lockport, New York) and manufactured aluminum bronze, an alloy of copper and aluminum containing about 10 per cent. of the latter metal, and ferro-aluminum, an alloy of iron and aluminum containing a little less than 10 per cent. of aluminum. The Cowles process, which has been frequently described, and is now well known to metallurgists, consists in passing the current from a powerful dynamo through a mixture of alumina (in the form of bauxite, corundum, etc.), carbon, and pieces of copper contained in a suitable vessel made of refractory material, lined with carbon, the electrodes of the dynamos being inserted through the ends of the vessel into the mixture. When the current passes, the alumina is reduced in the presence of carbon by the intense heat so produced, and the aluminum set free combines with the copper, which is in a molten state. No uncombined aluminum was made by this company, which confined itself to the production of alloys.

In 1888 the Pittsburg Reduction Company began to produce aluminum itself by means of dynamo electricity. The process employed consists essentially in forming a fused "bath" of fluoride of aluminum and sodium, either in the form of cryolite from Greenland or artificially prepared fluorides of a similar composition, adding some chloride of calcium to the bath, then alumina, and then passing the current from a dynamo through the bath from carbon electrodes. The fusion is effected by the heat of the current. The alumina is decomposed by this means and aluminum is set free. The process is continuous because fresh alumina is added as the old becomes used up, and the aluminum being heavier than the melted bath sinks to the bottom of the latter and is tapped off. The price of aluminum made by this company was $2 per pound in 1889 and its production in that year was 19,200 pounds. Its production has since been largely increased. The market price is now something less than $1 per pound. Processes like those just described are in operation in three places in Europe, and produce both alloys and metallic aluminum. The Deville-Castner process was inaugurated in England in 1888, the new start being due to the Castner method of manufacturing sodium at a cheap rate. This company turned out about 500 pounds of aluminum a day in 1888, but was extending its capacity to a much greater amount in 1889.

Altogether, therefore, we see that a new impulse has been given to the metallurgy of aluminum in the last two or three years and that a very greatly increased production may be looked for. Up to 1889 the production was very small compared with that of other metals whose uses in the arts resemble those of aluminum. An estimate made for the U. S. census by the present writer showed that the total amount of aluminum produced in the world up to the close of 1889 was, as far as could be ascertained, about 116 tons, but the probability then was that with the enlargement of capacity of new works, this figure would soon be exceeded by the annual production. It is very likely that this is already the case. But supposing it is, and that several hundred tons are produced annually, this would still be an insignificant figure compared with the amount of zinc or copper or tin which is consumed every year, and these are the metals which aluminum is expected to displace in some directions. The production of copper in 1889 (Merton & Co.'s compilation) was 262,990 tons, of zinc 330,000 tons, and of tin in 1886 40,000 tons. This comparison applies, of course, only when the present methods of production are considered. Some cheap and simple process would have to be invented whereby aluminum could be produced in large quantities to enable us to make any other comparison, and it would only be questioning possibilities to speculate in this direction at present.

Immediately upon the revival of interest in aluminum the newspapers began to speak of the "age of aluminum" as being close upon us, and as many new uses for the metal were suggested as the imagination of the writers could invent. This prophecy is yet unfulfilled and the uses of aluminum for manufactured articles are still of the same narrow range as formerly. There seem to be mechanical difficulties in working the metal which must be overcome before it will receive a ready welcome among metal workers, who at present are apparently a little shy of it. When it can be soldered, or welded, and otherwise worked, or cast, or used in plating and the like as easily as the other useful metals, it doubtless will be substituted more fully for them on account of the admirable qualities which it possesses for many purposes. But the new uses for manufactured articles which are really introduced and are not mere suggestions still have the old character. They are for instruments, such as mining transits, where lightness is of great importance, for kitchen and domestic utensils where resistance to corrosion is desired, and for many things of a similar character, *i. e.*, where lightness and strength and non-corrodibility are required, but nothing yet has been proposed for the metal in the large way, especially in the face of its price and production, sufficient to warrant us in believing that the "age of aluminum" has already dawned upon us, although it may be near at hand. Indeed, the place this interesting metal has hitherto occupied was pretty clearly mapped out by Deville thirty-five years ago. His words were: "I conclude that aluminum is susceptible by its peculiar properties—inalterability in air and in air containing sulphureted hydrogen, resistance to the action of acids except hydrochloric, fusibility, the beauty of its color, and its physical properties which make it comparable with silver—of becoming a metal of frequent use. Its density, which is nearly like that of glass, assures it special applications. Occupying a place between the common and precious metals by some of its properties, it is superior to the former for the usages of domestic life on account of the harmlessness of its combination with weak acids." This modest claim, after all, points out with accuracy the field of usefulness which aluminum has thus far covered for articles of manufacture. Its lightness, strength, and non-corrodibility have all been taken advantage of as far as prices would allow. But with the new start in production have come two new uses which have kept step therewith and deserve

special mention. These are its employment in making alloys and in the metallurgy of iron and steel.

Deville made several alloys with aluminum and described their properties and merits, and gave particular attention to the bronze, the peculiar properties of which have attracted attention from time to time since his day. But since its manufacture on a large scale by the Cowles company the commercial world has acquired a much closer acquaintance with this alloy and its use has been greatly extended. Its resistance to corrosion and great tensile strength (up to 72,800 pounds per square inch) have given it an extensive range in the arts, and it has been used for articles of all descriptions, from propeller wheels down to small articles of various kinds.

Its popularity may be inferred from the increase in its production, which rose from 4,000 pounds in 1885, the year the industry was established, to 145,000 pounds in 1887. Brass also, containing 3½ per cent. of aluminum, has a great textile strength (up to 82,300 pounds per square inch), and has been recommended for various purposes where strength and resistance to the action of acid fluids are requisites. Recently the field of experiment with alloys of aluminum has been reopened, and many new ones have been made and patented. Some of these contain only a small quantity of aluminum, while others consist almost wholly of it, a small quantity of some other metal being added to correct certain deficiencies of aluminum, such as want of rigidity, softness, etc. These alloys require a considerable amount of aluminum, and this line of experiment may result in causing a considerable increase in the consumption of the metal as time goes on. But the other use to which allusion has been made, which has come into existence in the last four or five years, is purely metallurgical and deserves particular notice, because it is very curious in itself, and has created a new demand for aluminum and its alloy ferro-aluminum.

Experiments made in Sweden in 1885 showed that the addition of very small quantities of aluminum (up to 0·1 per cent.) to molten iron and steel just before casting improved the quality of the casting in a remarkable degree. In explanation of this improvement it was erroneously supposed at that time that the melting point of the iron was lowered by the addition of the aluminum, just as the melting point of an alloy is lower than that of the least fusible of its constituents. This has since been disproved by direct experiment. However, the fact of improvement was incontestable, and manufacturers were quick to take advantage of the discovery, and a considerable demand for aluminum for this purpose was the consequence. The aluminum was added to the iron or steel principally in the form of the iron alloy ferro-aluminum containing about 10% of aluminum, which was found to be a useful vehicle for this purpose, and an idea of the sudden growth of the new use can be obtained from the increase in the production of that alloy in this country, the Cowles company having turned out only 2,500 pounds in 1885, the year this metallurgical practice began, while in 1887 the same company produced 42,617 pounds. Experiments made by Mr. Keep in Detroit, Mich., in 1888, confirmed the previous ones as to the beneficial effect which small quantities of aluminum produce upon iron and steel when added as described, but he went further and was able to specify in detail the particulars of the improvement. He showed, in a paper read before the Washington meeting of the American Institute of Mining Engineers, that aluminum, when used up to a certain point, increases the tensile strength of the iron and prevents blow holes in the castings, and he was the first to observe that aluminum has the faculty of causing carbon to separate in the uncombined form in the iron. These experiments of Mr. Keep's have been confirmed by others made in England and described in a paper read before the Iron and Steel Institute at the New York meeting by Mr. R. A. Hadfield. In these experiments it was shown that aluminum can decompose carbonic oxide at a very high temperature, and this reaction may account in part for the prevention of blow holes and the separation of carbon. It appears that the practice in England is to add the aluminum up to 0·15 per cent. of the charge of iron. It is clear that if this use is resorted to by iron manufactures to any considerable extent, it would require a large proportion of the aluminum produced every year under the present conditions to satisfy the demand so created, and indeed this use may account in large measure for the increased production of the last two years.

The following table presents in a convenient form the comparative positions of iron, steel, copper, and aluminum. It is taken from a paper read by J. H. Dagger, F.C.S., before the London Society of Chemical Industry in 1890. It should be remembered that different specimens of aluminum give somewhat different results to the tests, owing to slight differences in composition and in physical condition.

	Aluminum.		Iron.		Steel.	Copper.	
	Cast.	Rolled.	Cast.	Wrought.		Cast.	Rolled.
Color.....	Bluish white.		White.	Gray.			
Density.....	2·5	2·7	7·5	7·1 to 7·8	7·7 to 7·2	8·96	
Weight in lb. per cu. ft...	162		450	485	490	555	
Melting point	1300° F.		2,786° F	above 4,000° F	4,000° F.	1,990° F.	
Tensile strgth. in lb. per sq. in.....	20,000 to 25,000	30,000 to 35,000	15,680 (7 tons)	45,000 to 60,000 (20-27 tons)	60,000 to 90,000 30-45 tns	20,000	30,000 to 40,000
Elongation p. cent.....	14	3		7 to 22	5 to 15		20 to 40
Electric'l conductivity...	34			16		99	
Thermal cond'ctiv'y (silver=100)....	33·7			11·9		75	

A LUMINOUS waterproof paper, which may be of use in places not well adapted for the application of luminous paint, may be made from a mixture of 40 parts pulp, 10 parts phosphorescent powder, 1 part of gelatine, 1 part of potassium bichromate, and 10 parts of water

A REMARKABLE CRYSTALLINE FORM OF GYPSUM.

IN the course of a geological excursion that I made last summer with the auditors of the museum, in the cuttings of the new railway from Mantes to Argenteuil, and to which Mr. Ramond and Mr. Dollfus have devoted some interesting studies, I was informed, on passing the Triel station, that some fossil plants had recently been found in the rock. In reality, it concerned a beautiful specimen which is figured herewith, and which the possessor kindly gave me for the geological collection of the museum, where it is now deposited. It is a block of whitish magnesium marlstone in which very numerous crystals of gypsum of very small size have formed, and which, as may be seen, are arranged in such a way as to resemble, at first sight, branches provided with small leaves.

Each of these apparent leaves consists of a small, perfectly complete crystal belonging to the crystallographic variety designated by Hauy by the name of trapezian, and in which is recognized, as very preponderant, the faces g', m, and i. It must be added that, ordinarily, the faces, m and i, are very sensibly curved. The result is that the general contour, losing its angles, resembles so much the more the usual oval form of limbs of leaves. The dimensions of the crystals, moreover, are very small and do not exceed a few millimeters. The axis of each of these crystalline formations simulating a branch is determined by a very fine fissure in the marl that appears to have caused the grouping of the gypseous individuals. At various points this fissure is incrusted with compact gypsum.

The production of such an accident does not seem to be very easy of explanation, at least at first sight. It must be noted, however, that the marly medium seems to have given the crystalline molecules a special facility for grouping themselves symmetrically. We know, in fact, that all the beautiful crystals of sulphate of lime are derived, not from strata of gypsum rock, but from marly strata impregnated with selenitic water. Thus the beautiful macles, so well known on account of the luster that they exhibit by thin cleavage, are met with exclusively in the thick stratum of marl that exists between the base of the high mass and the summit of the second mass of gypsum rock. So, too, the plastic clay at Vaugirard, as well as at Auteuil and elsewhere, has for a long time furnished collections with the elegant rosulate crystallizations of gypsum that might be searched for in vain in the strata entirely formed of sulphate of lime.

In the interior of the masses we remark the same thing; and it is now a long time ago that I made known the existence at Annet, near Thorigny, at Argenteuil, at Soisy, and at other localities, of strata subordinate to the second mass, relatively rich in marly elements, and in which the gypsum, instead of being simply saccharoid, assumes a texture that may be qualified as porphyroid. We remark therein, in fact, among extremely fine and malformed elements, innumerable small gypseous lenses, whose slightly curved faces may be determined with precision. Moreover, the influence of a marly or argillaceous medium is shown in other crystals than those of gypsum.

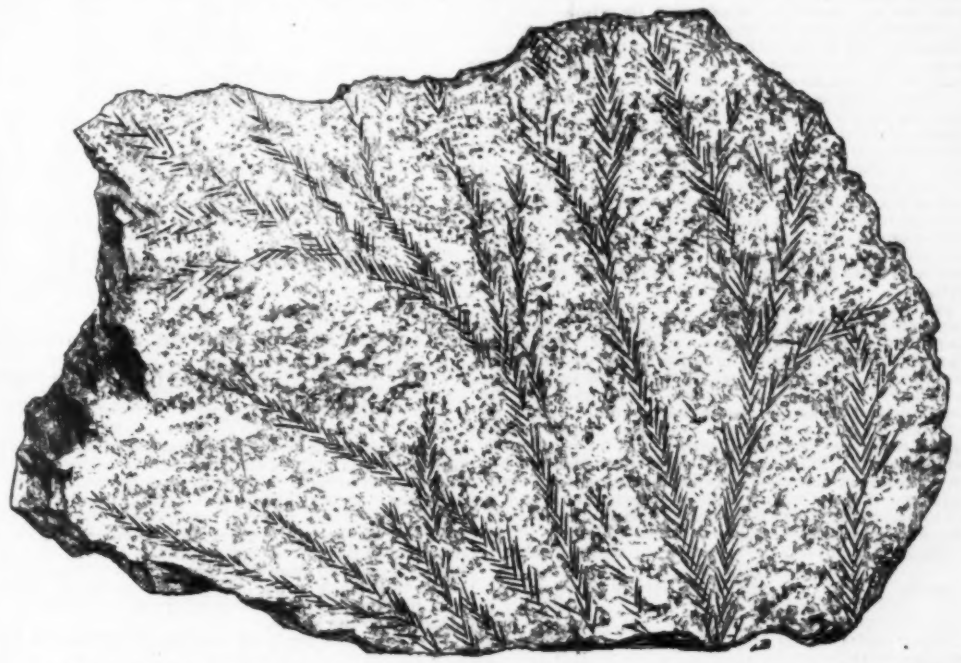
Rock salt frequently crystallizes apart from compact lenses and within incasing clays, and every one knows of the existence at the base of the gypseous deposit, as well as at other argillaceous levels, of the impressions of *sieves* derived from an insoluble mineral which can be nothing but rock salt, and which bears witness to the same fact.

This is the place, too, to note the fact that it is possible to put to profit, artificially, the conditions favorable to crystallization that so clearly belong to argillaceous pastes. It is many years ago that the elder Seguin wrote as follows:

"If clay be mixed with a solution of salt, and the mixture be made as thick as desired, and left to itself, we shall at the end of a certain time, and after the mixture has hardened, find in the interior of the mass crystallized portions of salt that have displaced the clay, while the saline portions have traversed the mass already in a solid state in order to unite at certain points and form regular crystals thereon."

I have, for my part, repeated analogous experiments in mixing clay with a solution of gypsum in hydrochloric acid, and also with a mixture of an aqueous solution of sulphate of soda and chloride of calcium in conditions in which, under the influence of supersaturation, the sulphate of lime does not deposit. In both cases I have obtained small, perfectly recognizable crystals of gypsum.

These facts, which are dependent upon the great chapter of molecular movements in solid masses, and with which are connected, for instance, the examples of formation of nodules of pyrites in chalk, are evidently applicable also to the production of crystals in the marl of Triel. The study of these will doubtless lead to interesting discoveries.—*S. Meunier, in Le Naturaliste.*



BLOCK OF MARLSTONE, SHOWING SMALL CRYSTALS OF GYPSUM SO ARRANGED AS TO RESEMBLE A PLANT.

[NATURE.]

THE RECENT EARTHQUAKE IN JAPAN.

AT 6:38 A. M. on October 28, I was awakened at my house in Tokio by the long, swinging motion of an earthquake. There was no noise of creaking timbers, and there were no shocks such as usually accompany earthquakes. It is an easy swing, which produced dizziness and nausea. As recorded by bracket seismographs this continued for ten or twelve minutes. During the interval there was ample time to study the movements of these instruments, and the conclusion that could not be avoided was that rather than acting as steady points these heavy masses were simply being swung from side to side—horizontal displacement was not being measured, but angles of tip were being recorded. That many of our seismographs are useless as recorders of horizontal motion whenever a vertical component of motion is recorded, is a view that I have held for many years, and therefore when these two have been recorded in conjunction, I have been inclined to receive the records with caution.

Further, the measurement of vertical motion as recorded by a horizontal lever arrangement can only be trusted if we can assure ourselves that the advance of the waves has been at right angles to the direction of the lever. If this condition is not fulfilled, then the seismograph for vertical motion may also become a tip-recording instrument. As another indication that during this particular earthquake earth tips occurred, I may mention that the water in a tank with perpendicular sides, which is about 25 ft. deep, 60 ft. long, and 30 ft. broad, rose quickly, first on one side and then on the other, to a height of 3 or 4 ft.—much in the same way that water would rise and fall in a basin that was being tipped from side to side.

Assuming what is said to be correct, it must not be concluded that modern seismographs are useless. For earthquakes where the motion is horizontal, they give records which practically are absolutely correct. When vertical motion occurs, in many cases if not in all, the records must be interpreted in a new light. The so-called horizontal displacements may be employed in determining the maximum slope of a wave, and if from an instrument recording vertical motion we are assured that we have measured the vertical height of a wave, we can at least approximate to the length of the same. The period of the waves being recorded, it follows that the velocity of propagation may be calculated.

Although it seems possible to use our present bracket seismographs as angle measurers, it is evident that there are other types of instruments, where swing due to inertia is minimized, which will act more satisfactorily. To obtain a true measure of vertical displacement, the most evident solution would be to use a number of lever arrangements in different azimuths. Other methods may, however, suggest themselves.

For the present our time is too much occupied with outside observations to attend to instruments or to reduce their records. Up to date it is known that nearly 8,000 people have been killed, many having been consumed in the burning ruins where they were entombed. At least 41,000 houses are level with the plain, and engineering structures which have stood both typhoon and flood have been reduced to ruin. In the middle of the stricken district, which is near Gifu and Ozaki, it is doubtful whether any ordinary building could have resisted the violence of the movement; but outside this much destruction might have been obviated had atten-

tion been given to the ordinary rules of construction, and to the special rules formulated by those who have considered the question of building in earthquake countries. In many places so-called "foreign" buildings of brick and stone—undoubtedly put up in the flimsiest manner—lie as heaps of ruin between Japanese buildings yet standing. Cotton mills have fallen in, while their tall brick chimneys have been whipped off at about half their height. Huge cast-iron columns which, unlike chimneys, are uniform in section, acting as piers for railway bridges, have been cut in two near their base. In some instances these have been snapped into pieces much as we might snap a carrot, and the fragments thrown down upon the shingle beaches of the rivers.

The greatest efforts appear to have been exerted where masonry piers carrying 300-feet girders over lengths of 1,800 feet have been cut in two, and then danced and twisted over their solid foundations considerable distances from their true positions. These piers have a sectional area of 26 by 10 feet, and are from 30 to 50 feet in height. Embankments have been spread outward or shot away, brick arches have fallen between their abutments, while the railway line itself has been bent into a series of snake-like folds and hummocked into waves. The greatest destruction has taken place on the Okazaki-Gifu plain, where we have all the phenomena—like the opening of crevices, the spurting up of mud and water, the destruction of river banks, etc.—which usually accompany large earthquakes. Okazaki and Nagoya the castles have survived. The reason for this may be partly attributable to the better class of timber employed in their construction, but principally to their pyramidal form and to the fact that they are surrounded by moats. Here and there a temple has escaped destruction, partly, perhaps, on account of the quality of materials employed in its construction, but also in consequence of the multiplicity of joints which come between the roof and the supporting columns. At these joints there has been a basket-like yielding, and the interstice of the roof has not, therefore, acted with its whole force in tending to rupture its supports. On the hills which surround the plain, although the motion has been severe, the destruction is not so great. These hills are granites, palæozoic schists, and other rocks. There is nothing volcanic. In the small cuttings where the railroad passes from the hills out into the plain, no effects of disturbance are observable, the surface motion probably having been discharged at the faces of the inclosing embankments. The general appearance outside the cuttings, however, is as if some giant hand had taken rails and sleepers and rubbed them back and forth until the ballast lying between them was formed into huge bolster-like ridges. Crossing the hills and proceeding to other plains, it is noticeable that there has been more movement on the alluvium than on the rocks.

Earthquakes yet continue, and in the Gifu plain each one is preceded by a boom as if a heavy gun had been fired in some subterranean chamber. Although the survivors, who may number, perhaps, two millions, are, for the most part, destitute, have witnessed the most terrible scenes, and are yet surrounded by the dead and the dying, yet there is no panic. They hear a "boomb," and run laughing to the middle of the street to escape the shock which the unaccountable noises herald. The Japanese have their feelings, but on occasions of this sort there is no helplessness in consequence of hysteria or mental prostration. As to what happens with Europeans under like circumstances, I must leave readers to consult history.

Tokio, November 7. JOHN MILNE.

HOW TO HARNESS AND UNHARNESS A HORSE.

MANY ladies are in the habit of driving about the country unattended by a groom, as those who drive in city parks usually are, but it is safe to say that not very many of these amateur drivers know much about the harness, or how the horse is put into and out of it.

A very interesting episode in a late novel is occasioned by the heroine's total ignorance of how to unharness the horse, and the dilemma she thus found herself in. Of course an elegant young man who knew all about everything in the world was at hand to assist her—and fall in love with her besides; but the average young woman cannot always be sure that such a gallant gentleman will be at hand when needed. She will, if ignorant of the uses and appliances of various parts of the harness, find herself very helpless in case of a trifling accident, not necessarily from want of strength and pluck to grapple with the difficulty, but from sheer ignorance.

For the sake of her own safety, every woman who drives at all should make herself thoroughly acquainted with the names and uses of every strap and buckle of the harness, and should be able, if necessary, to harness and unharness her horse herself. This is, of course, the groom's work; but it is assuredly wiser *for* a lady to understand the matter, in case of an emergency, as well as to detect any carelessness on the part of the attendant. A lady may return from her drive sooner than she expected, and find no one about the place to "put up" the horse; or she may wish to go out when there is no one around to harness the horse for her, and she will find it very convenient to know how to proceed in such cases.

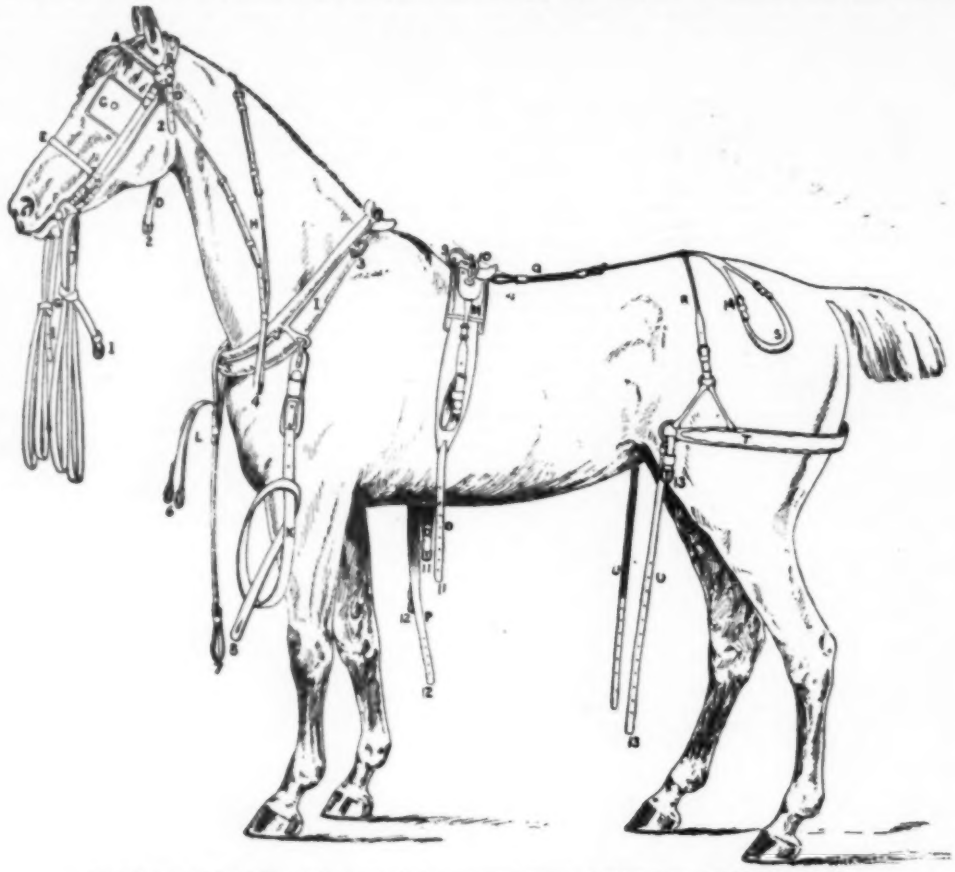
We illustrate and describe single harness only, because double harness is almost too much *for* a woman to manage alone, unless thoroughly familiar with all kinds *of* horses and harness, in which case she would need no written instructions. Single harness with breeching is illustrated, but it often happens that there is no breeching, even to single harness, as with some light carriages it is not really needed, except in hilly districts.

The first thing to do is to know each piece of the harness by its proper name. To do this, look over the harness well with the illustrations and list given herewith, and get your husband, father, brother, or groom to assist you to identify each separate piece of it.

There are three divisions of the harness which are put on separately and then fastened together, although to the uninitiated it is a mystery where the straps and buckles are located that are to be undone when the horse is unharnessed. A lady known to the writer, with more zeal than familiarity with the subject, find-

ing it necessary to unharness her horse, unbuckled every strap in the harness, and felt that she had demonstrated the ability of her sex to cope with matters usually considered clear only to the masculine understanding. Of course no irreparable damage was done; but fancy the feelings of the man whose duty it was to put that harness together again!

The first illustration shows the near, or left, side of a horse, with the harness placed in position, but unbuckled, as brought from the harness room. The lettering is explained by the list printed below the illustration, the harness comprising as follows: The bridle, consisting of brow band, head band, blinders, throat strap, nose band, and bit; the collar, to which are attached the hames, martingale, and traces (if a Dutch collar, only the two latter); and the saddle, to which are attached the inner belly band, the outer belly band, shaft tugs, back strap, crupper, hip straps, breeching, and holdback straps. The reins and check rein are attached to the bridle.

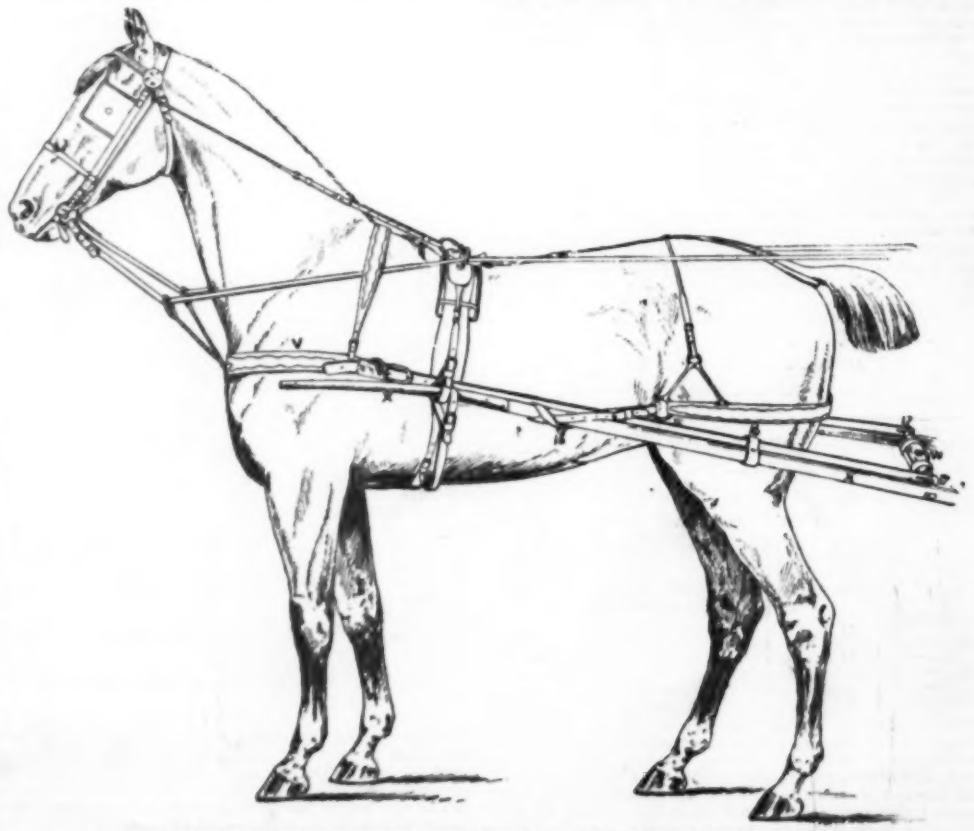


HARNESS PLACED ON A HORSE, WITH THE BUCKLES UNFASTENED.

A, brow band; B, head band; C, blinder; D, throat strap; E, nose band; F, bit; G, reins; H, check; I, collar; J, hames; K, trace; L, martingale; M, pad or saddle; N, shaft tug; O, inner bellyband; P, outer bellyband; Q, back strap; R, hip strap; S, crupper; T, breeching; U, holdback straps.

Now you are ready to harness the horse. A horse should always be approached on the near, or left, side. Of course some of the harness has to be fastened on the off, or right, side also. When the horse is taken out of the stable, begin, if the harness has a martingale (as illustrated), by putting on the collar: otherwise, the saddle and breeching may be put on first. The loop on the martingale has to be fastened under the horse with the inner belly band, which necessitates the collar being put on first, if the harness is used with a martingale. A Dutch collar (as shown in the illustration of horse completely harnessed) simply consists of breast and shoulder straps, and only needs to be put on over the horse's head. If the collar is a hame collar (as shown in the first illustration), pass it over the horse's head with the narrow end pointed downward, and as soon as you get it over his ears, on the narrowest part of the neck, twist it around so that the narrow end points upward.

If, however, the horse's head is too large to allow the collar to pass over without unfastening the hames, it will be necessary to undo the latter at S, and after the



HORSE COMPLETELY HARNESSED WITH A DUTCH COLLAR HARNESS.

V, Dutch collar; W, whiffletree; X, shaft.

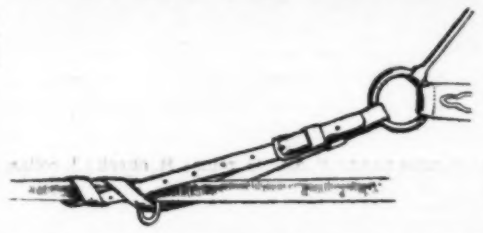
collar is in place put the hames on and buckle them again in front at 3. Then put on the saddle, drawing the crupper, which is attached to it by the back strap, under the tail. The horse may object to this, in which case you will find it necessary to unbuckle the crupper strap at 14, and put it around the tail and buckle it again. Then slip the loop of the martingale, 7, over the buckle, 11, of the inner belly band, and buckle the latter (11 and 11), making it tight enough not to slip in any way, yet not painfully tight. If the finger can be pushed under the belly band when buckled, it will be found about right. If the harness has no martingale, the saddle and back harness can be adjusted first, and then the collar put on.

Now you are ready to bridle the horse. Remove the

CURB BIT.

halter and catch hold of the horse's head by the forelock, with three fingers of the right hand, leaving the forefinger and thumb free, and having the bridle in the left hand. Pass the head piece of the bridle to the thumb and forefinger of the right hand, slip the bit into the horse's mouth with the left hand, and immediately raise the latter to assist the right hand to pull the head piece back over the horse's ears. If the horse refuse to open his mouth for the bit after two or three attempts, hold the bit to his teeth and press the under lip at the side, against the tooth very lightly at first, and then a little harder. It will hurt a little, and the horse will open his mouth. Sometimes a lump of sugar will accomplish the same object, and you can slip the bit in before the horse can object. A little coaxing and patting is a great assistance. Horses are very sensitive and susceptible creatures, and dearly love to be petted and praised.

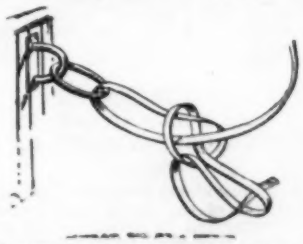
When the bit is in place, buckle the throat strap at 2 (throat latch, some call it). If the bit is an ordinary ring bit the bridling is complete, as illustrated; but with a curb bit (see separate illustration) the curb



HOLDBACK STRAP WOUND TWICE AROUND THE SHAFT.

chain hanging from the small ring of the bit must be twisted until it comes flat, and then hooked, passing under the horse's jaw to the curb chain hook on the opposite side of the bit. The curb chain should not be too tight: it should be loose enough to admit of a finger being easily inserted under it. The reins should be buckled in the slots of the curb next below the bit ring (see separate illustration of the curb bit). When buckled in the bit rings, they have no action on the curb, and are only buckled in the lower slots for exceptional cases when it is necessary to drive with a heavy curb.

Now your horse is ready for "putting to" the carriage. If the shafts are lying down, do not bring him near enough to walk on them, but lift them above his back, then draw up the carriage, passing the ends of the shafts through the shaft tugs on the sides of the saddle, taking care that the shaft on the right side passes also through the loop of the outer belly band, which, when the harness is taken from the harness room, will be found buckled, as the strap on the opposite side must be later. If the shafts are curved outward at the ends, the horse can be backed into them by taking hold of the looped reins hanging from the bridle



HOW TO TIE UP A HORSE.

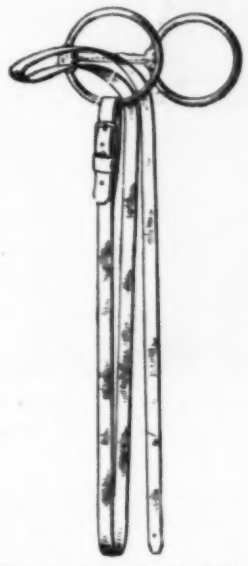
and urging him to step backward. It may be found more convenient to prop up the shafts and back the horse under them.

Uncurl the traces, run them first through the loops, 16, at the side of the shafts, and fasten them on to the trace hooks, 17, on each side of the whiffletree, and run the little tags on the whiffletree into the trace hooks.

Make the horse step up until the traces are taut, and then proceed to fasten the breeching, or holdback straps. Draw the tongue of the holdback strap under the trace and shaft and forward through the ring, or loop, on the shaft at 15, put it once over the shaft, slide the tongue of the strap backward under the strap around the shaft, and buckle back to the breeching at 13. This strap must go once or twice (or more times) around the shaft, according to the requirement of the harness. The breeching at the back must sag away a little from the horse's hind quarters when he has been made to step up till the traces are taut.

The separate illustration of the breeching, or holdback, shows the strap going twice over the shaft; but in every case the tongue of the strap, in going back toward the buckle, must be pushed under the strap wound around the shaft. The strap on the right side must be buckled over the shaft in the same manner, and the traces will then run free between the straps and the shaft.

Lastly, bring up the outer belly band on the left side, inside the shaft and forward of the shaft tug, run the tongue of the strap backward through the shaft tug, and buckle it over the shaft, back of the tug. To one



LOOPING REINS TO BRIDLE.

not accustomed to harness, this last strap may seem almost useless; but a very serious accident may occur from carelessness in buckling it: if it becomes unbuckled going down a hill, a horse has no chance to hold back the vehicle.

Now undo the reins, 1, pass them first through the rings on the martingale (if there be a martingale) at 6, then through the terrets on the harness, 3, then through the terrets on the saddle, 10, and buckle the ends of the reins together. Fasten the loop of the check rein, 4, into the check rein hook, 9, and your establishment is ready.

The second illustration shows the horse completely harnessed and ready for driving, but with the Dutch collar, which is not a collar, properly speaking, but an arrangement of straps, to be put on and the lower loop of the martingale, if one be used, secured when the belly band is buckled.

To unharness a horse is naturally to reverse the order of harnessing him. Unbuckle the ends of the reins and pull them out, one at a time, from the terrets, and loop them to the bridle, as shown in the separate illustration, folding the rein and drawing double through the bit ring, and tying the end about one-third of the way to the looped ends. Take the check-rein from the hook, unfasten the outer belly band on the near, or left, side; unbuckle the two holdback straps, pull them out of the rings or loops on the shafts, and slide the tongues through the buckle slides, 13; unhook the traces, pull them out of the shaftloops, 16, and loop them up as shown in the first illustration.

Push the shaft tugs forward on the shafts as near the ends as possible, take firm hold of one shaft, and walk the horse out of the shafts; then undo the inner belly band, and remove the saddle and breeching. Hang it up in the harness room by the top of the saddle and the back of breeching, and never by any of the straps. Turn the collar around, the narrow end pointing downward (if the hames will not pass over the horse's head they must be unbuckled and taken off first); unhook the curb chain, unbuckle the throat strap, and pull off collar and bridle together, if it is a hame collar. To do this, run your left thumb under the head band and draw it over the horse's ears, while with your right hand you are drawing off the collar. Let bridle and collar slip over the left arm while you slip the halter on the horse's head, buckle the throat strap on the halter, and tie up the horse.

Some horses know enough to untie an amateur knot; but we illustrate a way of tying the horse which makes a knot impossible for any one of the equine grade of intelligence to undo with their teeth. Put the end of the halter, or tie strap, upward through the ring to which you are going to tie the horse, turn the end once under the slack of the rope, double the end to form a loop, put it over the rope, and draw the looped end through the first turn made. Now draw it up tightly. Pull up the slack of the rope, which will carry the knot to the ring, and put the end of the halter, or strap, through the loop. To untie it, pull out the end from the loop and give it a sharp pull, and the cord, or strap, will hang loose in the ring.

When you have tied the horse, hang up the collar, narrow end pointing downward, and the inside outward, so it will dry; and the bridle by the head piece.
—*Mary Martingale, Demarest's Family Magazine.*

THE HISTORY OF ASTRONOMY.*

G. F. CHAMBERS, F.R.A.S.

EVERY science has a history, and it will often happen that a due presentation of the facts of that history and a due comprehension of their bearing will greatly aid an intelligent reader in his study of the particular science in its modern aspects. All this is particularly true of astronomy. A student who has mastered the facts appertaining to its origin in early times, and to its subsequent development down to the present epoch, should have acquired a considerable general knowledge of the science itself as a whole.

Poetry and romance have always talked about the Chaldean shepherds as the first astronomers. I can neither affirm nor deny the idea. But when one considers how much time men of the shepherd class spend out in the open air, and how accurate their anticipations of the weather generally are, it seems not unreasonable to think that such men as the shepherds of eastern lands may have been in a certain general sense the earliest astronomers.

This conception naturally suggests the question, "Do we find any allusions to astronomical matters in the Holy Scriptures?" To this the answer must be in the affirmative. Of historical events there are two, the astronomical import of which is very obvious. (1) The standing still of the sun and moon, as so stated, at the command of Joshua,* and (2) the going back of the shadow of the sun for King Hezekiah's sake on the dial of Ahaz.†

The former of these events has never been adequately explained, and it can only be regarded as having been a miracle in the proper sense of the word. With respect, however, to what happened in the case of Hezekiah there seems reason to believe that the observed facts may be reconcilable with the circumstances of a partial eclipse of the sun, visible as such at Jerusalem on January 11, 689 B. C. This eclipse is known to have happened nearly at noon, and if we may suppose the words "dial of Ahaz" to apply to a large gnomon or sundial formed of masonry, and similar in character to such a structure as that which still exists at the ruined Hindu observatory at Benares, we may understand that a shadow caused by an uneclipsed sun might be brought back on the upper part of the sun's disk suddenly ceasing for an hour or so to be a source of light.‡

Passing from Asia into Europe, we come to the Greeks, of whom it may be said generally that they were great astronomers as well as physicists. The names of Thales, Pythagoras, Anaximenes, Meton, Eudoxus, Philolaus, Aristotle, Calippus, Archimedes, Aratus, Aristarchus, Eratosthenes, Apollonius and Hipparchus will readily occur to the mind. They were perhaps not all Greeks in the strict literal sense of the word, but may virtually be regarded as such, bearing in mind the school of thought (to use a hideous modern term) to which they belonged. Two or three of those mentioned, such as Thales, Aristotle, and Hipparchus, were giants in science, comparable with the Humboldts and Herschels of the present century. This remark is peculiarly true of Hipparchus. The work which he performed really laid the foundations for the science of exact astronomy as distinguished from mere star gazing.

The labors of Hipparchus were as varied as they were important. He discovered the precession of the equinoxes; was the first to use right ascensions and declinations; probably invented the stereographic projection of the sphere; suspected that inequality in the moon's motion afterward discovered by Ptolemy and known as the evection; calculated eclipses; and formed the first regular catalogue of stars in consequence of having observed a temporary star burst forth in 131 B. C.

After the Christian era the first illustrious name which appears on the pages of astronomical history is that of Ptolemy of Alexandria, who lived from 100 A. D. to 170 A. D. He was both a writer and an observer. His great work was the celebrated *Μεγάλη Σύνταξις*, better known by its Arabian designation of *The Almagest*. This work contains, among other things, a review of the labors of Hipparchus; a description of the heavens, including the Milky Way; a catalogue of stars; sundry arguments against the motion of the earth, and notes on the length of the year. To Ptolemy we owe the discovery of the lunar evection, of the refractive properties of the atmosphere, and of the theory of the universe which bears his name.

It is a remarkable fact that, great as they were in almost every department of life, the Romans utterly failed as men of science. Perhaps it would be more accurate to say that they never tried their hands at physical science. This is the more remarkable when we remember how great they were in everything else. They were great lawyers, great engineers, great statesmen, great generals, great scholars, great poets, great even in medicine and surgery, but as sailors they obtained but moderate success, while for physical science they have left us nothing to show.

During the first half dozen centuries of the Christian era, Alexandria may be regarded as having been the great center whence astronomical knowledge was disseminated throughout the world. But in 640 A. D. the Alexandrian school was broken up by the Saracens under Omar. In the following century, on the building of Bagdad by the Caliph Al-Mansar, that place became the great center of astronomy, and continued to be such for 400 or 500 years.

The names which have come down to us in this connection are not numerous, but they are individually weighty. Grouping together various writers and workers under the general name of Arabic or oriental astronomers, we fall in with the following: Albategnius, Alfraganus, Al-Sufi, Ebn Yunis, and Abul Wefa. Albategnius (*circa* 880 A. D.) may be regarded as the most distinguished astronomer between Hipparchus and Tycho Brahe. He discovered the motion of the solar apogee, corrected the value of precession and of the obliquity of the ecliptic as previously received, formed a catalogue of stars, and was the first to use sines and chords. Al-Sufi (d. 986 A. D.) was a distinguished Persian astronomer, who left behind him a very curious and interesting catalogue of stars, of which a translation into French was published by Schjellerup at St. Petersburg, in 1874. Ebn Yunis and Abul Wefa both lived about the year 1000 A. D., and greatly developed the use of trigonometry. The latter is thought by some to have discovered the lunar inequality known as the variation.

In 1079 we find a Persian astronomer of the name of Omar proposing to reform the calendar by interpolat-

* From Pictorial Astronomy for General Readers, June, 1891.

* Joshua x. 13.

† II. Kings xx. 11.

‡ All the details of this are very well worked out in Mr. J. W. Bosanquet's *Messiah, the Prince*, 8vo, London, 1865, p. 176 *et seq.*

ing one day in every fourth year, but postponing to the thirty-third year the interpolation belonging to the thirty-second year. This would have produced an error of only one day in 5,000 years, whereas the error arising in the Gregorian calendar, adopted five centuries later, and which we now use, amounts to one day in 3,845 years. The acuteness and research of this Persian philosopher may well excite our surprise and admiration.

The translation of Ptolemy's *Almagest* from Arabic into Latin, and the work done in Spain under the patronage of Alphonso X., King of Castile, indicate a movement of astronomical knowledge in a western direction over Europe. Accordingly the revival of letters, the invention of printing, and a taste for geographical research, cultivated especially by the English, the Portuguese, and the Spaniards, gave a great impulse to the exact sciences, and of course to astronomy among them. Hence it follows that work and workers multiply all over Western Europe, Germany taking the lead. The names of several of the famous men of the 16th and following centuries have already occurred in these pages in connection with particular items of work which they did, and with the results which they left behind. It may serve to fix some of these names in the mind of the reader if I enumerate a few of these men, and the centuries in which they died.

During the 16th century we have Regiomontanus, Copernicus, and Jordanus Brunus. The first two were working astronomers in the fullest sense, but Jordanus Brunus was rather a philosophical speculator on astronomical subjects than, strictly speaking, a working astronomer.

In the 17th century we find Tycho Brahe (d. 1601), Fabricius (d. 1616), Kepler (d. 1630), Galileo (d. 1642), Torricelli (d. 1647), Descartes (d. 1650), Gassendi (d. 1655), Hevelius (d. 1687), and C. Huygens (d. 1695). This century produced the first star atlas, by Bayer, a work which constituted a new departure in astronomical records; the refracting telescope; the discovery of spots on the sun; the discovery of the satellites of Jupiter and of Saturn; observations of transits of Venus and Mercury; pendulum clocks; the reflecting telescope; the discovery of the progressive transmission of light; and important investigations into the theory of the moon. In 1666 Flamsteed commenced observations at Greenwich Observatory, and by so doing laid the foundations for that great and prolonged development of scientific work there which inspired Bessel, half a century ago, to say that if all the books on astronomy in the world, and all the observatories in the world, except Greenwich, were destroyed by some great catastrophe of nature, the whole science could be reconstructed from its foundation by means of the knowledge gathered up and stored at the Greenwich Observatory.

All things considered, the 18th century did not show such an advance over the 17th as the progress of learning and the multiplication of telescopes might have led us to expect. Although Newton lived on till the year 1727, yet he belonged much more to the previous century, his immortal *Principia* having been published as far back as 1687. The first and greatest of the five generations of the Cassini family who have left their mark on French astronomy (Jean Dominique), though he died in 1712, yet performed all his important work (and very important it was) during the second half of the 17th century. The names which should be picked out and attached to the 18th century are only Leibnitz (d. 1716), who was more a mathematician than a scholar, Flamsteed (d. 1719), J. P. Maraldi (d. 1729), Halley (d. 1742), Bradley (d. 1762), La Caille (d. 1762), Ferguson (d. 1776), Pingre (d. 1796), and Le Monnier (d. 1799). A detailed inquiry into the circumstances of the 18th century discloses the general fact that the French came very much to the front as observers and mathematicians; that the Italians to a considerable extent, and the Germans almost entirely, receded into the background; while the progress of the English was chiefly in regard to practical matters, such as nautical astronomy and navigation, clocks, chronometers, and time appliances generally, and the construction of astronomical instruments of precision. But we must not pass away from the 18th century without noting two very important points of progress, the invention of the achromatic object glass by Dollond, and Sir W. Herschel's success in the manufacture of the reflecting telescopes, and the use of them.

The progress of astronomy during the 19th century has been so absolutely great that it is quite hopeless to give even a sketch of it. However, nearly all the facts which belong to this century, together with the names of the men, and some of the dates, have already been brought before the reader in previous chapters. The only points which it seems possible to specify are: the great progress in the construction of large astronomical instruments, and the application of photography and of the spectroscope to astronomical purposes. But besides these general points, it is impossible not to be struck with the remarkable growth of the science in England in the hands of amateurs; in Germany in the hands of government establishments; and in America in connection with universities, colleges, and semi-public observatories endowed by deceased benefactors. These are three well-marked national differences of *modi operandi* on which a political astronomer would probably feel inclined to comment at length, and from which to draw moral lessons.

EXTRAORDINARY LUMINOUS PHENOMENON OBSERVED ON THE SUN.

ON the seventeenth of June, 1891, at 10 h. 16 m., mean time of Paris, Mr. Trouvelot was projecting the image of the sun upon a screen, when his attention was aroused by an extraordinary luminous phenomenon. Quite close to the western limb of the luminary there was observed a luminous spot subtending an angle of 8", and which far surpassed in brightness the most brilliant faculæ that had ever been observed by him.

The light was not white like that of the faculæ, but slightly yellowish, and bore a striking resemblance to that of an incandescent lamp just before it has acquired its maximum luster. A minute later, there appeared a little to the north of this object a sort of narrow facula parallel with the limb, from which it was not far distant, and which extended over an arc of 5° or 6° and emitted the same quality of light, but a little less brilliant.

After two or three minutes of observations, Mr. Trouvelot adapted a spectroscope to the telescope, and having directed the latter toward the corresponding place of the solar limb, observed a violent eruptive center situated at 281°, from which were escaping a sort of extra incandescent volcanic bombs, which were shot upward to 6 or 10 ft. above the chromosphere. Despite its brilliancy, the phenomenon did not correspond to

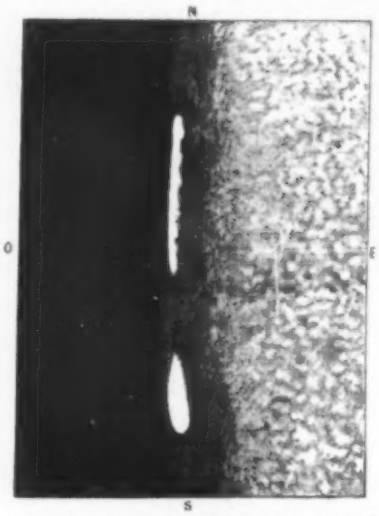


FIG. 1.—LUMINOUS PHENOMENON OBSERVED UPON THE SUN JUNE 17, 1891, AT 10 H. 16 M.

the intense disengagement of light observed at first, and it became evident that it had grown fainter during the few minutes that had elapsed while the spectroscope was being adjusted. In order to assure himself of this, Mr. Trouvelot quickly substituted the ocular for the spectroscope and found, in fact, that where intense luminous spots had shone a few minutes previously there was not to be seen even a trace of the faintest facula. Having put the spectroscope in place, he found that the protuberance had still the same luster, but that the sparkling bombs had disappeared, and were replaced by numerous filaments that rose to greater heights.

At 10 h. 24 m., these luminous rays reached a height of 534", say 139,000 miles. At noon the eruption was

FIG. 2.—ERUPTIVE PROTUBERANCES OBSERVED ON JUNE 17, 1891, AT 10 H. 21 M.

not quite so violent, but the luminous rays were still brilliant and extended to a great height.

On the eighteenth of June, at 9 h. 30 m., the eruptive energy of the protuberance was still intense, and its rays reached a great height, but the activity further and further diminished, and, at 2 h. 43 m., calmness was re-established and every trace of the protuberance had disappeared. On the same day, at 5 h. 30 m., another observer, Mr. Jules Fenyi, remarked at the same place a group of protuberances forming the seat of an exceedingly violent eruption. The detached parts of this group, which, at 5 h. 42 m., reached a height of 109 seconds, displaced themselves with the prodigious velocity of from 180 to 340 miles per second.

The rapid development of these projections, which

FIG. 3.—THE SAME PROTUBERANCE OBSERVED AT 10 H. 24 M.

passed from 111 to 227 seconds in height, indicated a velocity of nearly 300 miles miles per second in the visual line. The resultant of these two simultaneous motions therefore attained at times 600 miles per second. If the phenomena observed were due to a matter possessed of such a velocity, it is evident that these masses must have been projected into space, and have escaped the attraction of the sun.

In concluding his communication, Mr. Trouvelot compares these eruptions with those that were observed on the first of September, 1859, and asks whether, like the latter, the eruption under consideration was accompanied with magnetic disturbances. The answer is furnished by the English journal, *The Observatory*, which gives diagrams, for June 17, of the

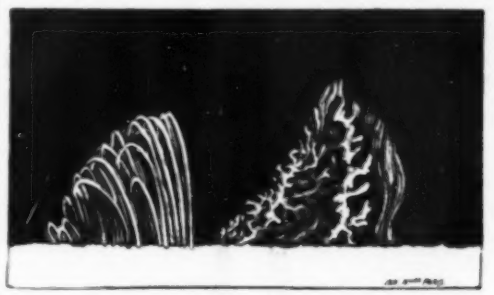


FIG. 4.—ASPECT OF THE PROTUBERANCES JUNE 18, AT 9 H. 30 M.

Greenwich Observatory apparatus for registering magnetic variations.

It will be seen (Fig. 6) that at 10 h. 7 m. (Greenwich time), that is to say, a few seconds previous to Mr. Trouvelot's observation, the diagrams show a simultaneous disturbance of the magnets. These variations, however, are less pronounced than those of 1859 which Mr. Trouvelot alludes to.

On another hand, two photographs of the solar disk were taken—one at 10 h. 19 m. 53 s. (Greenwich time)

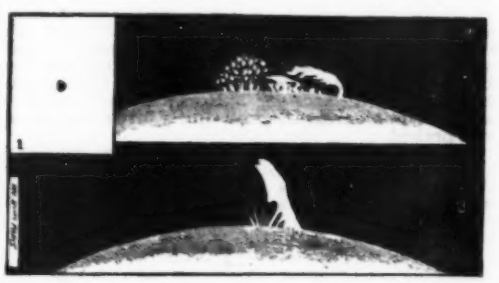


FIG. 5.—COMPARATIVE DIMENSIONS OF THE EARTH, SUN, AND HEIGHT OF THE PROTUBERANCES AT 10 H. 21 M. AND 10 H. 24 M.

that is to say, 13 m. and 45 m. later than the moment at which Mr. Trouvelot was making the curious observations that we have just described. Both of these photographs show the faculæ described by the French astronomer.

Fig. 1 shows the aspect of the phenomenon of the seventeenth of June at 10 h. 16 m.; Fig. 2 shows the height reached by the protuberances at 10 h. 21 m.; Fig. 3, their height at 10 h. 24 m.; Fig. 4, the appearance of the protuberances observed on the eighteenth of June at 9 h. 30 m.; Fig. 5 shows the height reached

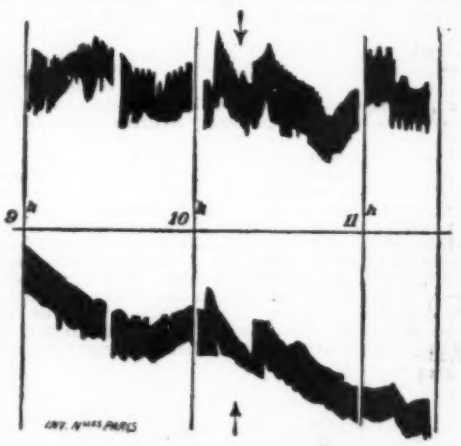


FIG. 6.—CURVES SHOWING THE MAGNETIC DISTURBANCES OBSERVED AT THE GREENWICH OBSERVATORY ON JUNE 17.

by these projections above the solar disk, as compared with the diameter of the earth; and Fig. 6 indicates the magnetic variations observed on the seventeenth of June at the Greenwich Observatory.—*Inventions Nouvelles.*

WINTER FLOWERING CARNATIONS.

CUTTINGS of these plants struck in early spring, and which are now in small pots, and have been stopped, will have formed three or four shoots on each, and if they are to be grown during the summer in pots, they should be potted into those which they will occupy for that period. In most cases 32's will be large enough, as nothing is gained by giving them more root space than is required for good growth. A suitable compost for carnations consists of rich fibry loam, such as that obtained from grass land fed off by stock, and to this, which should have been stacked one year at the shortest, some rotten manure and sharp sand should be added. The drainage must be good, and at least one and a half inches deep, so as to insure the rapid exit of the surplus water. When the young shoots have grown

some four inches in length, the points may be again pinched out, and the shoots arising from this act of stopping will be found sufficient to furnish the plant. After potting them, stand the plants in an open, sunny place, either on boards or plunged to half their depth in a bed of fine coal ashes. On the first appearance of aphides or of mildew, either of which, if allowed to go on unchecked, will soon ruin the plants, dip the plants in weak tobacco water for the first and dust affected parts with flowers of sulphur for the second.—*The Gardener's Chronicle.*

AZOIMIDE, N_3H—THE NEW SODIUM SALT—THE MOST HIGELY EXPLOSIVE SUBSTANCE KNOWN.

THE discovery of this remarkable compound of hydrogen and nitrogen by Prof. Curtius, in the chemical laboratory of the University of Kiel, formed one of the most interesting chemical events of last year. The extraordinary nature of the compound—manifested by its fearfully explosive properties, together with its acid character, by virtue of which it forms salts with metals containing only metal and nitrogen—mark out for it a place among the most attractive of hitherto discovered substances. It was first obtained by Prof. Curtius in the form of a gas, by treating with soda a compound containing the organic radicle benzoyl in the place of the hydrogen atom, and subsequently warming the sodium salt thus produced with dilute sulphuric acid. The gas was described as possessing a frightfully penetrating odor, and as being absorbed by water with extreme avidity, forming a solution of strongly acid properties, which liberates hydrogen in contact with metals. So great, indeed, is the affinity of azoimide for water, that in these earlier experiments it was not found possible to collect the gas in the anhydrous state. Shortly after the publication of his first communication (see *Nature*, vol. xlii., p. 615), an improved method of preparing the solution in water was devised by Prof. Curtius. It consisted in distilling a soda solution of a derivative containing the radicle of hippuric acid with dilute sulphuric acid. He was thus enabled to obtain a tolerably large quantity of the aqueous acid. By a successive fractionation of this solution in water, and finally distilling the last product of the fractionation over fused calcium chloride, pure azoimide itself was eventually isolated, and found to be a volatile liquid, boiling at 37°

Owing to the terribly explosive nature of both the free acid and its salts, the work has been attended with considerable danger, and has, unfortunately, been delayed by a lamentable accident which befell Prof. Curtius's assistant, Dr. Radenhausen, who was seriously injured by the explosion of a quantity of the anhydrous acid. At length, however, Prof. Curtius is able to publish some further particulars concerning the acid and its salts, and an important communication from him will be found in the current number of the *Berichte* of the German Chemical Society. The following is a brief account of these further researches, together with a *resumé* of the present state of our knowledge of this interesting compound and its derivatives.

Sources of Azoimide and its Derivatives.

Azoimide and its salts have been obtained from two distinct sources, both organic. One source, the first employed by Prof. Curtius, is benzoyl-glycollic acid, $C_6H_5CO—O—CH_2COOH$; the second is hippuric acid, $C_6H_5CO—NH—CH_2COOH$. During the investigation of the reactions of this previously discovered compound of hydrogen and nitrogen, hydrazine, N_2H_4, Prof. Curtius found that both benzoyl-glycollic and hippuric acids reacted with hydrazine hydrate, forming hydrazine derivatives.

Benzoyl-glycollic acid reacts with two molecules of hydrazine hydrate, forming benzoyl hydrazine, $C_6H_5CO—NH—NH_2$, and the hydrazine derivative of acetic acid, $NH_2—NH—CH_2COOH$, with elimination of water. When benzoyl hydrazine is treated with nitrous acid, it is converted into a nitroso derivative,

$$C_6H_5CO—N\begin{cases}NO\\NH_2\end{cases}$$

This nitroso compound is a very unstable substance; it spontaneously parts with water, and becomes converted into the benzoyl derivative of azoimide, benzoyl-azo-imide,

$$CH_5CO—N\begin{cases}N\\\|\\N\end{cases}$$

This latter compound forms a direct starting point for the preparation of azoimide. Upon boiling with alkalies an alkaline salt of azoimide is formed, together with benzoate of the alkali. Thus with soda

$$C_6H_5CO—N\begin{cases}N\\\|\\N\end{cases}+2NaOH=$$

$$C_6H_5COONa+NaN\begin{cases}N\\\|\\N\end{cases}+H_2O$$

When the sodium salt of azoimide is distilled with dilute sulphuric acid, azoimide escapes as a gas, which condenses along with water in the form of an aqueous solution.

Hippuric acid reacts with one molecule of hydrazine with formation of hippuryl hydrazine, $C_6H_5CO—NH—CH_2CONH—NH_2$. When this substance is treated with nitrous acid, a compound is obtained which was at first considered to be a nitroso compound, but is now discovered to be in reality a diazo compound possessing the constitution $C_6H_5CO—NH—CH_2CONH—N=N—OH$. This substance may be isolated in quantity, and yields salts of azoimide directly upon treatment with alkalies. If soda is employed the sodium salt of azoimide is obtained, from which azoimide itself may, as before, be liberated by distilling with dilute sulphuric acid. It is more convenient, however, as will be described later, to employ it directly for the preparation of the ammonium salt of azoimide by saturating its alcoholic solution with ammonia gas; from the ammonia salt, if desired, azoimide itself may be obtained by converting it into the insoluble silver salt, and distilling the latter with sulphuric acid.

Preparation and Properties of the Sodium Salt of Azoimide, Na—N<N‖N

The method of preparing the sodium salt of azoimide now adopted as most convenient by Prof. Curtius is somewhat different from the earlier one just described, although based upon the same lines. Instead of benzoyl glycollic acid, ethyl benzoate, $C_6H_5COOC_2H_5$, is employed. This substance is converted readily into benzoyl hydrazine by treatment with hydrazine hydrate:

$$C_6H_5COOC_2H_5+N_2H_4.H_2O=$$
$$C_6H_5CONH—NH_2+C_2H_5OH+H_2O$$

This benzoyl hydrazine is next treated with sodium nitrite and glacial acetic acid, whereby it is quantitatively transformed into benzoyl azoimide, the benzoyl derivative of the new acid:

$$C_6H_5.CONH—NH_2+HNO_2=C_6H_5CO—N_3+2H_2O$$

The benzoyl azoimide thus obtained is finally dissolved in an equal weight of absolute alcohol, and the equivalent of an atom of sodium is also dissolved in a little absolute alcohol, and the two solutions mixed; the mixture is then digested for several hours upon a water-bath, when the sodium replaces the benzoyl radicle, and ethyl benzoate is regenerated:

$$C_6H_5CO—N_3+C_2H_5ONa=C_6H_5COOC_2H_5+Na—N_3$$

Upon cooling, the solution deposits crystals of the sodium salt, and the remainder may be precipitated from the mother liquor by means of ether. The ethyl benzoate is recovered by distillation with very little loss, and may be employed again for the preparation of a further quantity of the sodium salt of azoimide.

The sodium salt, NaN_3, obtained by this method is substantially pure. It is very soluble in water, but is, strangely enough, not hygroscopic. It is almost insoluble in ether and alcohol. It gives a feebly alkaline reaction, and possesses a briny taste. The crystals do not explode by percussion, but do explode when heated to a temperature which is higher than in the case of most other salts of azoimide. The explosion is accompanied by the production of a brilliant yellow flame and a detonation which is less loud than in the case of other salts. The salt is not volatile, and is not changed by evaporation of its aqueous solution.

Preparation and Properties of the Ammonium Salt NH₄—N<N‖N

The ammonium salt, which is by far the most convenient salt to start with for the preparation of the free acid and its metallic salts, is best prepared from the curious diazo compound of the amide of hippuric acid, $C_6H_5CO—NHCH_2CO—NH—N=N—OH$, before mentioned. This substance is readily obtained in calculated quantity by first acting with hydrazine hydrate upon the ethyl ether of hippuric acid, and subsequently treating the hippuryl hydrazine thus produced with sodium nitrate and glacial acetic acid. Diazo-hippuramide appears to be most prolific in its reactions. Prof. Curtius states that it reacts with almost every class of organic and inorganic bodies with which he has brought it in contact, and generally without the application of external heat. Thus, when treated with water, alcohol, haloid ethers (alkyls), aldehydes, free halogens, or hydrazine derivatives of organic acids, it evolves free nitrogen gas, and forms compounds which are derived from hippuramide by replacement of a hydrogen atom in the NH_2 group by the radicle of the reacting substance. On the other hand, when acted upon by alkalies, ammonia or substituted ammonias (amines), or by diamide (hydrazine) and its derivatives, salts of azoimide are formed. This last reaction, when ammonia is employed, forms the most convenient mode of obtaining the ammonium salt of azoimide.

About a pound of diazo-hippuramide is placed in a flask of 2 liters capacity, and covered with 600 grms. of 85 per cent. alcohol. The flask is then placed in a freezing mixture, and ammonia gas is led in until the liquid is saturated with it. The flask and contents are then allowed to stand twenty-four hours in order to complete the reaction, when the diazo compound is quantitatively converted into hippuramide and the ammonium salt of azoimide:

$$C_6H_5CO—NHCH_2CO—NH—N=N—OH+2NH_3=$$
$$C_6H_5CO—NHCH_2CONH_2+NH_4—N_3+H_2O$$

The liquid is then boiled, the flask being fitted with an upright condenser, until no more ammonia escapes, when the heat is removed, and the solution allowed to cool. After standing another twelve hours, the clear alcoholic solution is decanted from the mass of hippuramide crystals, and treated with four times its volume of ether, when 70 per cent. of the total yield of the ammonium salt is precipitated in the form of a white powder. The remaining 30 per cent. of the azoimide may be recovered by recrystallizing the hippuramide from water, adding the mother liquor to the ethereal alcoholic solution after removal of the precipitated ammonium salt, and treating the whole of the liquid with solutions of lead, silver, or mercurous salts, when the azoimide is precipitated in the form of the difficulty soluble lead, silver, or mercurous salts. The hippuramide is readily converted, by boiling with hydrazine hydrate, into hippuryl hydrazine, which may thus be used again for the preparation of more of the diazo compound.

The precipitated ammonium salt is washed with ether and dried in the air. The snow-white crystalline powder thus obtained, consisting of fine anisotropic needles, may be recrystallized from boiling alcohol. It is only sparingly soluble in absolute alcohol, but on boiling for some time in a flask fitted with inverted condenser, the whole passes into solution. Upon cooling, the salt separates out in large colorless crystals, tabular in form, and frequently aggregated in step or fan shaped forms. These aggregates often resemble those of ammonium chloride very closely, but the crystals do not belong to the cubic system. The crystals are readily soluble in water, and, upon allowing the aqueous solution to evaporate *in vacuo*, large transparent prisms are obtained, which, however, soon become turbid in air.

The ammonium salt of azoimide reacts in a feebly alkaline manner. It is not hygroscopic, although so readily soluble in water. It dissolves easily in 80 per cent. alcohol, but, as above described, with difficulty in absolute alcohol. It is insoluble in ether and benzene. It is distinguished by its great volatility. When the crystals are allowed to lie exposed to air, they gradually disappear, eventually passing away entirely in the form of vapor. Upon gently warming a small quantity of the salt in a test tube to a temperature very slightly superior to 100°, it sublimes like ammonium chloride, condensing again, however, in brilliant little prisms. This operation requires great care, for if the heating proceeds too rapidly, the substance explodes with great violence.

As may be expected, great difficulties were met with in obtaining an analysis of a substance so explosive. Upon attempting to determine its composition by combustion with copper oxide in a stream of dry air, the apparatus was destroyed upon each occasion with a fearful detonation. Only one-tenth of a gramme of the salt was employed, placed in a small platinum boat. At first the compound sublimed out of the boat into the cooler portion of the combustion tube; the little sublimed crystals then commenced to fuse into yellow drops, and immediately this occurred, in each experiment, the tube was shattered to fragments with a frightful report. The platinum boat was in each case torn to fine splinters. Eventually, however, Prof. Curtius succeeded in obtaining a satisfactory analysis by performing the combustion with copper oxide in a stream of carbon dioxide.

The ammonium salt may be readily converted into the sodium salt by evaporation with caustic soda upon a water bath.

Preparation and Properties of Free Azoimide, H—N<N‖N

An aqueous solution of azoimide may be prepared by distilling any of its salts, preferably the sodium or silver salts, with dilute sulphuric acid. It is more conveniently obtained, however, by dissolving the crystals of diazo-hippuramide in dilute caustic soda, warming the solution for a short time upon a water bath, so as to insure the formation of the sodium salt, and subsequently distilling the liquid with dilute sulphuric acid. The latter is allowed to drop slowly from a dropping funnel upon the soda solution contained in a flask and maintained at the temperature of ebullition. The flask is connected with a condenser, and the azoimide, as it escapes, is carried along with the steam, and condenses in the receiver in the form of an aqueous solution. This solution may be concentrated by precipitating it with silver nitrate, collecting the insoluble silver salt, and distilling it with sulphuric acid diluted with eight times its volume of water.

The aqueous solution of azoimide possesses a most intolerable odor.

Free azoimide itself may be obtained by the fractional distillation of the concentrated aqueous solution thus prepared. The first fraction is collected separately and refractioned. Upon repeating this process with four successive first fractions, an acid containing over 90 per cent. of azoimide is obtained, which distills at about 45°. The last 10 per cent. of water may be completely removed by means of fused calcium chloride, after treatment with which pure anhydrous azoimide distills over.

Azoimide is a clear, colorless, mobile liquid, which boils without decomposition at 37°. It is endowed with the same intolerable odor as the solution. Its most characteristic property, however, is its frightful explosiveness. It explodes in a most erratic manner—sometimes without the least apparent provocation, at the ordinary temperature. Its distillation is an operation attended by great danger. Prof. Curtius and his assistant *have* succeeded, as above described, in isolating it and determining its boiling point several times; but upon other occasions, under apparently the same conditions, the experiment has ended with a disastrous explosion. When suddenly heated or touched with a hot body, it always explodes. The explosion is accompanied by an intensely vivid blue flame. The damage wrought by the explosion of very minute quantities is most surprising. The thousandth part of a gramme, placed upon an iron plate and touched by a hot glass rod, is sufficient to produce a loud detonation, and considerably distort the iron plate. The twentieth part of a gramme was found sufficient to completely pulverize a Hofmann "density" apparatus, when an attempt was made to determine it vapor density in the Torricellian vacuum at the ordinary temperature. Upon another occasion, seven-tenths of a gramme, contained in a closed glass tube, upon removal from the freezing mixture in which it had been immersed exploded with such an immense force as to shatter every piece of glass apparatus in the laboratory. It was upon this occasion that Prof. Curtius's assistant was so seriously injured as to cause the temporary abandonment of the work. The aqueous solution is almost as explosive as the anhydrous liquid, the explosion of two cubic centimeters of a 27 per cent. solution upon one occasion shattering the glass tube into dust so fine that Prof. Curtius, who was attempting to seal it, escaped uninjured.

The anhydrous liquid readily dissolves in water and alcohol. The aqueous solution is strongly acid to litmus. Magnesium, aluminum, zinc, iron, and even copper are rapidly attacked by it, hydrogen being evolved. Gold and silver are likewise attacked, although not so rapidly. In the case of gold a red solution of the gold salt is formed; the silver salt being insoluble soon prevents further action in the case of silver.

The anhydrous compound appears to be decomposed by *concentrated* sulphuric acid.

Other Metallic Salts of Azoimide.

The silver salt, $Ag—N<N‖N$, is obtained in the form of a white precipitate whenever a soluble silver salt is

added to azoimide, its aqueous solution, or solutions of its salts. It resembles silver chloride very closely in appearance, but is not darkened by the action of light. There is very little difficulty in distinguishing between the two salts, however, inasmuch as the silver salt of azoimide partakes of the frightfully explosive properties of the free acid. It is the most dangerous of all the salts to handle. In spite, however, of this explosiveness, Prof. Curtius has *once*, and only once, succeeded in obtaining a determination of its nitrogen content, by combustion in a long layer of copper oxide. The number obtained was 27·65. The value calculated from the formula AgN_3 is 28·00. In every other experiment the tube was shattered into fragments, notwithstanding the finest subdivision and distribution among the copper oxide.

The precipitated silver salt is soluble, like silver chloride, in ammonia. Upon evaporation of the solution, however, instead of obtaining an ammoniacal double compound, the silver salt itself crystallizes out in almost colorless crystals half an inch long. These crystals, as may be imagined, are most delicate objects to handle; they explode even upon breaking the prisms across. They are almost perfectly insoluble in water.

The mercurous salt, HgN_6, is likewise insoluble in water, and may be readily obtained by precipitation of the free acid or its soluble salts with mercurous nitrate. It has the advantage of being more safely handled than the silver salt, and it is less sensitive to percussion. It also requires a higher temperature to bring about explosion by heating. It is usually obtained by precipitation in the form of microcrystalline anisotropic needles. It becomes colored yellow when exposed to light. Like mercurous chloride, it forms a black compound with ammonia.

The lead salt, PbN_6, resembles lead chloride very closely. It is insoluble in cold water, but dissolves somewhat in boiling water, though not to such an extent as lead chloride, about half gramme dissolving in a liter of boiling water. Upon cooling, brilliant colorless needles, attaining sometimes the length of half an inch, separate out. It may be best obtained by precipitating the solution of the sodium or ammonium salt with lead acetate. The precipitate is soluble in excess of lead acetate. The crystals of the lead salt explode with fearful force when slightly warmed. By long boiling with water this lead salt appears to be decomposed, a non-explosive lead compound separating, and free azoimide escaping. Warm acetic acid also dissolves it, with gradual decomposition and liberation of azoimide.

The barium salt, BaN_6, is readily obtained by neutralizing the acid with baryta, and crystallizes from solution in large lustrous crystals. It is likewise a highly explosive salt, and the explosion is accompanied by the production of a brilliant green flame.

Ethereal Salts of Azoimide.

The metallic salts of azoimide may be readily converted into ethereal salts by reacting upon them with haloid ethers. The phenyl ester has been prepared by Prof. Curtius and found to be identical in every respect with the long known diazobenzene imide, $C_6H_5N{<}^{N}_{N}$

The aromatic esters are generally remarkably stable substances, and it was consequently found impossible to obtain azoimide by the direct saponification of diazobenzene imide with soda. Within the last few months, however, Drs. Noelting and Grandmougin, of Mulhausen, have succeeded in preparing azoimide indirectly from diazobenzene imide, by first diminishing somewhat the stability of the compound by introducing two nitro groups into it. Upon treating dinitro diazobenzene imide with alcoholic potash, the potassium salt of azoimide was at once formed. Upon distilling this with dilute sulphuric acid, an aqueous solution of azoimide was obtained, and eventually anhydrous azoimide itself, identical in all respects with that obtained by Prof. Curtius.

Hydrazine Salt of Azoimide, $N_3H \cdot N_2H_4$.

This interesting substance, formed by the union of equal molecules of the two remarkable compounds, hydrazine and azoimide, whose isolation we owe to Prof. Curtius, is a solid substance forming large well-defined crystals. It is obtained when one molecular equivalent of hydrazine hydrate (the preparation and properties of which were described in *Nature*, vol. xliii. p. 205) is added to the ammonium salt of azoimide, and the mixture, placed in a shallow dish, is allowed to evaporate in a desiccator. It is curious, also, that by adding a very concentrated aqueous solution of azoimide, obtained by distilling 60 grammes of the lead salt with dilute sulphuric acid, to hydrazine hydrate, until litmus is turned strongly blue by the mixture, one does not obtain, as might be expected, the salt $2N_3H \cdot N_2H_4$; on the contrary, the mono-salt, $N_3H \cdot N_2H_4$, is again formed; and if the mixture is placed in a desiccator containing solid caustic potash and oil of vitriol, crystals of the mono-salt are deposited, and the excess of azoimide escapes and is absorbed by the potash.

The mono-hydrazine salt crystallizes in lustrous, anisotropic prisms an inch long, which melt at 50°. They rapidly deliquesce in air. They are soluble with difficulty in boiling alcohol, and crystallize from the solution, on cooling, in brilliant leafy crystals. The crystals burn quietly with a smoky flame when brought in contact with a flame, leaving no trace of residue. Owing to the strong reducing power of the liberated glowing hydrogen, metallic surfaces upon which the crystals may be ignited become brightly cleaned, as if polished, being freed from the least trace of oxide. When the crystals, however, are rapidly heated, or touched with a white-hot wire, they explode with fearful violence. The explosion may also be brought about by detonating in the neighborhood a little of one of the metallic salts of azoimide. Even in the deliquesced state the substance retains its fearfully explosive properties.

In conclusion, it may be remarked that Prof. Curtius has further succeeded in preparing a number of derivatives of the as yet unisolated compound of hydrogen and nitrogen, triamide, $NH_2—NH—NH_2$, by action of the hydrazine compounds of several organic acids upon diazo-hippuramide. The organic radicles are so rigidly attached in these derivatives that he has not yet been fortunate in displacing them. It appears very probable, however, that before long some means of effecting this object will be discovered, and that Prof. Curtius will further add to his achievements by making us as familiar with triamide as we now are with hydrazine and azoimide.—*A. E. Tutton, Nature.*

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